SF 99. F5 D4

UNIVERSITY OF B.C. LIBRARY
3 9424 05125 184 8

PR OLUMBIA

FISHERIES DEPARTMENT

卐

EDIBLE FISH-MEAL

Its Composition and Value with Instructions for Its Use in Feeding Cattle, Swine, Sheep, and Poultry

Edited by
RODNEY DELISLE
Department of Agriculture

VICTORIA, B.C.:
Printed by CHARLES F. BANFIELD, Printer to the King's Most Excellent Majesty.
1930.

STORAGE ITEM
PROCESSING-ONE
Lp1-E20A
U.B.C. LIBRARY

PROVINCE OF BRITISH COLUMBIA

卐

FISHERIES DEPARTMENT

卐

EDIBLE FISH-MEAL

Its Composition and Value with Instructions for Its Use in Feeding Cattle, Swine, Sheep, and Poultry

Edited by

RODNEY DELISLE

Department of Agriculture

VICTORIA, B.C.:

Printed by CHARLES F. BANFIELD, Printer to the King's Most Excellent Majesty.

1930.

INTRODUCTION.

THIS bulletin is issued by the Provincial Fisheries Department to meet the increasing demand for information as to the composition of edible fish-meal, now so extensively produced in the Province, its value in the feeding of cattle, sheep, pigs, and poultry, and giving instructions for its use.

It gives a review of the researches, experiments, and results in many countries in the feeding of edible fish-meal to domestic live stock and poultry, and is written not only for the farmer who desires to improve his live stock through better feeding methods, but also for those engaged in the production of fish-meal.

The Provincial Fisheries Department, Victoria, will be pleased to reply to any specific questions that may arise as to the best use of edible fish-meal used in feeding.

SAMUEL LYNESS HOWE,
Commissioner of Fisheries.

Victoria, B.C., October 29th, 1930.

Digitized by the Internet Archive
in 2010 with funding from
University of British Columbia Library

http://www.archive.org/details/ediblefishmealit00brit

HISTORY.

Relation of Fishing to Agriculture.—The history of the manufacture and use of fish-meal is one which is certain to excite the interest of all those engaged in agriculture. It involves a lot of the romance of the sea and of those who go " down to the sea in ships." Agriculture and fishing are more closely related than would at first be supposed, for between them they provide the only remaining sources of food for both man and animals—early food supplies in the form of wild animal life no longer being considered of any importance. From the earliest times fishermen have been farmers, and farmers along the sea-coasts have been fishermen. And just as farmers then, as now, are intensely interested in the economical conversion of waste products into foods for human consumption, it is not surprising that the fisherman-farmer concerned himself with the economical conversion of the waste of the fisheries into animal foods. It is, therefore, to these pioneers we owe a debt of gratitude for their work in solving, to no mean extent, the foremost problem of the farmer to-day—that of economical production of foods for human consumption.

Farmers and Fishermen produce Waste.—In other ways, too, fishing and farming resemble each other. Both of them involve the harvesting of crops at the expense of hard labour. The farmer, however, must sow before he reaps his harvest, and though this is not now true of the fisherman, it may some day be the case also. Just as the farmer now harvests much that he finds little use or sale for, the fisherman does likewise. Science is finding a use for the waste products of the farm—witness the manufacture of building material from waste sugar-cane; but, on the other hand, the farmer is finding a use for the waste products of the sea, as, for instance, the increasing use of fish-meal made from fishery wastes and inedible fish, of which tremendous quantities are produced every year.

Minerals in Ocean come from Land.—The farmer and the fisherman have still another bond of common interests. Just as the sea is producing food for the farmer's crops, in the way of fertilizers, and food for his animals, in the way of dried fishery wastes in the form of edible fish-meal, so is the farm and all the land providing the food of fishes; for it is quite true that all of the minerals in sea-water which support life therein had their origin in the land and have been carried to the sea by the rivers. Nowhere else in nature can a more interesting cycle of events be found—not, at least, to the modern farmer.

Erosion and Leaching to blame for Losses.—From the very beginning of the present geological age the soil has been subjected to a continuous process of leaching. Thus many of the most important elements essential both to plant and animal life—as, for example, iodine, to mention only one—have been finding their way to the sea to be irrevocably lost, except as certain products of the ocean are subsequentiy either consumed as food or applied to the soil as fertilizer. Only in this way may those valuable products, of which the soil has for so long continuously been robbed, be restored to the animal or human organism.

No Records of Earliest Uses of Fish-meal.—There is very little doubt but that fishery wastes have been consumed by domestic live stock since the earliest times—probably for centuries—but it is apparently only in more recent times that accurate records have been kept of the results obtained. More than likely the reason for there not being more early records of the feeding of fish-meal available is because of a feeling which has always existed that such a product was not a " natural " one for domestic live stock; these early fishermen-farmers did not, therefore, wish to " tell the world " of their practices even though all of them had adopted the practice because of its inherent soundness, both from the point of view of economy and of animal health.

Use of Fish-meal is Old-established Practice.—The soundness of any practice may be established either as a result of very long usage, or it may also be established in a very short time as a result of scientific endeavours on the part of those most interested in the

particular product under trial. In the case of fish-meal, both methods have been used in establishing the worth of this product.

Ancient and Modern Methods both prove Value of Fish-meal.—At the time of its earliest uses means were not at hand, or even known, by which determinations could be made of its intrinsic value, but by the "cut-and-try" methods then in vogue it was established that fish wastes in a dry form could be used to advantage as a feed for domestic live stock, and all that modern science is able to do in this connection is to produce an explanation of the beneficial results obtained. Irrespective of whether or not science had ever delved into the principles involved in the feeding of fish-meal to domestic live stock, the practice would still be in force, for it has been handed down from father to son for many generations. Indeed, it was in this way that the idea of feeding fish-meal to live stock in British Columbia got its inception.

Old Habits and Modern Methods combined.—In this fair Province of ours, "Where East meets West," we have a peculiar blending of Old World traditions with New World progressiveness difficult to find in any other part of the world. And because of this, farming practices are a delightful mixture of good old "cut-and-try" methods and the most modern methods established by science. For instance, on countless farms throughout British Columbia one can find the very finest of modern dairy-barns, the cows in which are being fed the "oldest of the old" protein concentrates—fish-meal. This happy state of affairs takes a rather strange trend, however, and one not so easily explained, and it is this: The younger generation of farmers who are not so well versed in Old World practices approach the idea with some hesitancy owing, perhaps, to a preconceived notion that the idea of feeding fish to domesticated animals is new; as soon, however, as the idea was shown to them to be older than their fathers, they have quickly adopted this "time-proven" practice, with the result that consumption has increased from less than 100 tons in 1928 to over 3,000 tons in the year ended March 31st, 1930—and this for the use of dairy cows and swine only, poultry consuming nearly 1,000 tons more.

Less Concentrates imported since Use of Fish-meal begun in B.C.—It was Old World farmers who first drew our attention to this "new" protein concentrate, fish-meal. Not even though fish-packers in British Columbia had been making it in ever-increasing quantities for several decades did we realize that we were producing at home a protein concentrate far and away superior to any similar product which we had been importing. A few years ago our farmers were importing concentrates in tremendous quantities from the four corners of the world, but in 1930 there is a different story to tell, for these same farmers have turned towards British Columbia fish-meal with a thoroughness which is characteristic of all their practices.

Earliest Recorded Trials of Fish-meal.—Amongst the farmers in British Columbia, as in every other country, is to be found the skeptical individual who appears to thrive best on facts, and though recorded data on the use of fish-meal in live-stock rations do not seem to go farther back than 1835, there is such an abundance of authentic reports since that time to more than satisfy the most skeptical individual we are likely to meet. It is no less an authority than Dr. Atwater, who tells us about the use of fish-meal nearly a whole century ago. If reports do not come "thick and fast" after that date it may be because writing was not such an easy job then as it is to-day; but, even so, we find a record dated 1864 in which it is stated that fish-meal or "pommace" was fed to sheep, swine, and poultry and that they thrived on it then—just as they do now. Five years later (in 1869), Wilder, in Maine, a member of the Board of Agriculture for that State, told of his experiences in the feeding of fish-meal or fish "offal" to sheep. He believed "fish-offal to be not only cheaper but much superior to any other kind of provender he had ever used" for such a purpose.

German and American Research in 1875.—Possibly some further reports were made before this next one we noticed dated 1875, in which year Farrington, also of Maine, reported some further experiments at the Maine Agricultural College on sheep. In this

same year Kellner reports some experiments which were made in the two previous years by Weiske, again using sheep as the experimental animals. In the next twenty-five years a lot of experimental work was done, and Schenke in 1902 reports fish-meal being fed to nearly every class of domestic animals (including dairy cows) with the same highly satisfactory results which have always been obtained.

Canada also Experiments with Fish-meal.—We can skip the next fourteen years, which brings us to 1916, and, incidentally, we come back home to Canada and arrive at the Central Experimental Farm at Ottawa, where a number of experiments were conducted by Archibald.

Canadian Reports are Interesting.—His very interesting report of these trials is given in full in the Dairy Cattle section of this bulletin (page 20). As this is the first report of the use of fish-meal in the dairy ration, of a Canadian source, it will be read with a great deal of interest.

Oily Fish-meal Proven not Objectonable.—At just about this time (1915–16) the Dairy Division, U.S. Department of Agriculture, carried out some experiments on dairy cows also, but using a fish-meal that was notable for its high oil content. If these experiments did nothing else, they did at least settle, for all time, the once-debatable question about the merits of oil in fish-meal, for up to this time fish-meal containing not more than 3 per cent. oil was considered the best; but the report states: "In these tests the feeding of fish-meal had no detrimental effect on either the milk or butter."

Fish-meal compared with other Concentrates.—In the decade just ending reports of the use of fish-meal in the feeding of all classes of domestic animals are "too numerous to mention." So much has been done towards establishing the merits of fish-meal as a live-stock feeding-stuff that further reports no longer excite the interest that they once did; but, in another way, our interest is held by reports of experiments wherein fish-meal is compared with other more common protein concentrates such as linseed-oil cake and with cottonseed-meal. In the Dairy Cattle section of this bulletin you will find detailed reports of results obtained when fish-meal was compared with both of these concentrates. The experiment carried out at Agassiz will be of particular interest to British Columbia dairymen, as the results obtained there confirm the opinion of the foremost dairymen in this Province.

Fish-meal is Oldest Protein Concentrate.—In concluding the history of the manufacture and use of fish-meal, it would be appropriate to remind readers of this bulletin that fish-meal is "the oldest of the old" protein concentrates and that its long-continued use throughout the world is all the evidence of its merit that is required. We may, therefore, consider its uses for particular purposes such as the feeding of dairy cows, sheep, swine, poultry, etc., and for the sake of convenience this bulletin is divided into sections for each class of live stock.

FISH-MEAL.

Its Composition and Value as a Feeding-stuff for Cattle, Swine, Sheep, and Poultry.

PREJUDICE AGAINST FISH-MEAL.

Chances of Taint not Understood.—"One of the reasons for fish-meal having been neglected is a feeling amongst a section of the agricultural community that, if fish-meal is used in the feeding of animals, the flesh will necessarily become tainted. That this idea is unwarranted is shown by the strikingly successful use of fish-meal as a feeding-stuff in British Columbia and elsewhere.

Only Great Excess can cause Taint.—"The prejudice probably arose from the fact that pigs, ducks, and poultry which are reared in the various fishing villages have a fishy taste when eaten, the assumption being accordingly made that, if fish-meal is used as a feeding-stuff, the result will be the same. This is not the case, as the taint which is so often present in the flesh of the pigs and poultry fed in the fishing villages is due, not to the fact that they are fed with fish, but to the fact that they are allowed to have an excessive and unlimited diet of fish. Fish-meal is a very rich and readily digestible food, and should be given moderately, and the recognized proportions, which are referred to later, should not be greatly exceeded. If this is kept in view, no taint in the flesh of the animal will result.

Discretion in Feeding must be used.—"Some farmers who have tried it have not found fish-meal satisfactory as a feeding-stuff, but this has been due to the reason that they have not used it with understanding. If a farmer gives it to his stock in large quantities, it is not to be wondered at that it should prove unsatisfactory, as it is a highly concentrated food, and has a strong, peculiar, although not unpleasant odour of its own. If moderate proportions are not exceeded and the fish-meal is gradually added to the ration, its efficiency as a feeding-stuff will soon become apparent.

WHOLESOMENESS AND FLAVOUR.

Raw Material is carefully selected.—"In the manufacture of fish-meal, the material from which it is made is selected both with a view to providing sound, reliable raw material and to ensuring the appetizing flavour which is desirable in all feeding-stuffs. In the process of manufacture the material is subjected by heating to a very high temperature, ensuring complete sterilization, with the result that all micro-organisms which might be present are wholly destroyed.

COMPOSITION OF FISH-MEAL.

Fish-meal contains no Carbohydrates.—"Fish-meal contains about 55 to 65 per cent. protein, about 4 to 8 per cent. of oil, and practically no carbohydrates. The composition of fish-meal varies, within limits, according to the nature of the raw material available for its manufacture. It will be seen that fish-meal is very high in protein; in fact, it is higher in protein than any other of the ordinary feeding-stuffs, and this renders it specially suitable for combination with feeding-stuffs which contain a low percentage of protein, such as roots, potatoes, hay, straw, and the cereal grains and offals. The oil is present in a good proportion compared with other foods. The carbohydrates, however, are so low as to be negligible. Fish-meal, therefore, being rich in protein, may be regarded as a builder-up and maintainer of flesh, muscle, and tissue.

High Mineral Content.—"Phosphate of lime is also necessary in a feeding-stuff, as the bones of the animal are built up and maintained by this constituent, and as fish-meal contains about 10 to 16 per cent. of phosphate of lime, it is well provided in this respect.

Need for Oil in Feeds.—" The oil in fish-meal may be taken as about 4 to 8 per cent. It is therefore fairly rich in oil as compared with other feeding-stuffs. Animals need oil in their food, and it is better to use a feeding-stuff in which oil is naturally present than to use one deficient in oil and supply the want by pouring oil over the feeding-stuff. In the latter case the oil is not emulsified, whereas in the former the oil naturally present is in the easily assimilated form of microscopically small globules."

OILS AND FATS FROM FISH.

Composition.—" The dietary value of fish-oils, like that of fats and oils obtained from land animals and plants, depends on a number of factors, the principal ones being their composition or nature, digestibility, and vitamin content.

Factors influencing Odour of Fish-meal.—" The fats from land sources consist largely of the glycerides of oleic, palmitic, and stearic acids. In addition to these, fish-oils contain others to a greater or less extent. Various investigators have submitted experimental evidence to show that from fish-fats one may obtain jecoric acid, jecoleic acid, therapic acid, and culpanodonic acid. The discovery of the presence of the glycerides of culpanodonic acid in marine-animal fats was of more than scientific interest, for Tsujimoto, a Japanese investigator, has apparently shown that the characteristic fishy odour of these fats is due very largely to this substance. When the glyceride of culpanodonic acid was removed from marine fats, or by hydrogenation was transformed into a glyceride of some other fatty acids, the characteristic odour of fish-fats disappeared.

Chemical Nature of Fish-oils.—" In considering the nature of fish-fats there is one factor that should be given attention—their tendency to oxidize and become rancid. Considered chemically, fats may be divided into three groups—drying, semi-drying, and non-drying oils. Oils that can absorb relatively large amounts of oxygen are called drying oils and are in demand for use in paints. The best-known member of this group is linseed-oil. Next comes the semi-drying oils, or those which can take up some oxygen but not enough to make them good paint oils.

Difference between Animal and Fish Oils.—" While fish and marine-animal oils differ from the terrestrial-animal oils to some extent as regards colour, odour, and viscosity, they are quite different chemically. The terrestrial-animal oils resemble closely the non-drying oils in that they do not easily absorb oxygen. The fish and marine-animal oils resemble the drying oils and have the power to absorb oxygen.

Comparative Digestibility of Animal and Fish Oils.—" Hundreds of digestion experiments have been conducted to determine the extent to which the edible fats from land plants and animals are utilized by the body. These show that the liquid fats as a class are more completely utilized by the body than are the solid fats. While in some instances there is little difference between the digestibility of solid fats and that of the liquid fats, there may be a differenece of 10 or 12 per cent. between the digestibility of the more completely digested liquid fats and that of the less completely digested solid fats.

" Applying this generalization, one would conclude that the digestibility of edible fish-fats would be quite similar to that of vegetable fats.

Results of Digestion Experiments of Fish-oils.—" The results of digestion experiments conducted by the writer while employed at the United States Department of Agriculture show that fish-fats are well utilized by the body. In studies with fresh mackerel and butter-fish and canned salmon and dogfish, the digestibility of the fat was found to be 95 per cent. for Boston mackerel, 86 per cent. for butter-fish, 94 per cent. for dogfish, and 94 per cent. for salmon.

" From this limited data concerning the digestibility of fish-fats one is inclined to conclude that they are quite satisfactorily utilized by the body."—*Arthur D. Holmes.*

Oil in Fish-meal is not Objectionable.—For the benefit of the lay reader perhaps it should be mentioned here that the foregoing references to oils and fats in fish are intended to mean oils and fats *as such* and not simply the residual oil which is found in fish-meal as sold for animal-feeding. It is quite true that fish oils and fats can, and do, become rancid when kept under poor conditions, but in all our experience with fish-meal, even that which contained as much as 15 per cent. oil, we have yet to see a sample of rancid meal. Prospective purchasers of fish-meal need not, therefore, concern themselves with the possibility that British Columbia fish-meal will become rancid in storage. As a matter of fact, many feeders have a preference for fish-meal which is a year or so old as the odour is much less pronounced as the meal ages.

DESIRABILITY OF OIL IN FISH-MEAL FOR STOCK-FOOD.

High or Low Fat Content of Fish-meal?—"In the German market a fish-meal containing a low percentage of oil (from 2 to 4 per cent.) is considered the best grade of meal. On the Pacific Coast the extraction of the oil by means of gasoline is being considered in the manufacture of fish-meal in that locality. With a lower fat content a higher protein content is obtained, which is, of course, desirable. On the other hand, *the fat, which is highly digestible, has a definite food value, and since it has been shown by experiment that high-grade fish-meals of high fat content have been fed with no apparent taint being imparted to the final product,* it is believed that the extraction of a fish-meal to a fat content lower than that which could ordinarily be obtained by thorough and efficient pressing would be unnecessary. This is particularly apparent when it is considered that fish-meal is to be used in relatively small quantities as a source of protein in balancing the rations of stock and in preparing the finished commercial stock feeds.

Effect of Rancid Oil in Fish-meal.—"Further, it is believed that any trouble that may have been attributed to a high fat content in the meal probably was due to rank, rancid oil, developed in decomposing raw material. Such oil is not present in meal prepared from fresh, undecomposed fish and fish wastes. Certainly a fat content of 14.56 per cent. in a meal of this character, as in that made from the waste in the packing of sardines, would appear to be satisfactory, since no flavour or taint of fish was imparted to eggs, milk, or butter in the experiments which were conducted with it."—*U.S. Department of Agriculture Bulletin No. 378.*

PROTEIN CONTENT OF FISH.

Quality of Fish Proteins.—The figures in Table No. 2 show that the percentage amounts of the various amino-acids in fish are directly comparable with those in the casein of milk, and it is therefore obvious that the addition of fish-meal to a vegetable-cereal ration for the dairy cow makes it possible for her to produce all the milk she is hereditarily fitted to give, without any drain upon the reserves of these compounds in her body-tissues. This fact has been repeatedly demonstrated in a large number of dairy herds in British Columbia.

Amino-acids in Fish.—Referring again to Table No. 2, it will be seen that "These data indicate that the tyrosine, arginine, histidine, and lysine content of fish and milk proteins are about the same. In general it may be said that the proportions of amino-acids found in fish proteins are approximately the same as those found in milk, except that the proteins of fish are curiously low in glycine, an amino-acid not essential in the diet.

Value of Fish Proteins.—"Thus, it is seen that fish proteins are valuable sources of nitrogenous substances for the nutrition of man and other animals, for they are complete proteins, lacking only in the simple amino-acid glycine, which can be formed in the body by the splitting of other amino-acids.

Abundance of Growth-promoting Amino-acids.—"The presence of considerable amounts of tyrosine, tryptophane, lysine, histidine, and arginine is noteworthy, as these amino-acids are essential for proper nutrition. Fish proteins also have been shown to contain

adequate amounts of valine, leucine, and phenylalanine, which are valuable constituents of proteins and are also considered essential by many nutrition experts.

Comparison of Fish and Cereal Proteins.—" Cereal proteins are, for the most part, deficient in arginine, histidine, and lysine. The amounts of these three amino-acids contained in many restricted diets are the limiting factors that determine their value for maintenance and growth."—*Tressler.*

TABLE No. 2.

Comparison of Amino-acids of Milk, Corn, and Fish.

	Casein (Milk).	Zein (Corn).	Fish.
1. Glycine	0.45	0.00	0.00
2. Alanine	1.85	13.39	*
3. Valine	7.93	1.88	0.79
4. Leucine	9.70	19.55	10.33
5. Proline	7.63	9.04	3.17
6. Oxyproline	0.23	*	*
7. Phenylalanine	3.88	6.55	3.04
8. Aspartic acid	4.10	1.80	2.73
9. Glutamic acid	21.77	26.17	10.13
10. Oxyglutamic acid	10.50	2.50	*
11. Serine	0.50	1.02	*
12. Tyrosine	6.50	3.55	2.39
13. Cystine	0.50	0.85	1.32
14. Arginine	3.81	1.82	6.34
15. Histidine	2.84	0.82	2.55
16. Lysine	7.62	0.00	7.45
17. Tryptophane	2.20	0.00	1.25
18. Ammonia	1.61	3.64	1.33
	93.62	92.58	52.82

* Not determined.

MINERAL CONSTITUENTS OF FISH.

Importance of Mineral Matter in Fish.—" It must be admitted that chemists have neglected the inorganic in favour of the organic constituents of fish. The analysis usually made give data concerning fat, protein, etc., but the 'ash' has not often been completely analysed. This neglect seems the more noteworthy in that one of the most important distinctions of fish in comparison with other foods exists in the inorganic constituents.

TABLE No. 3.—PERCENTAGE OF MINERAL ELEMENTS IN FLESH OF VARIOUS ANIMALS.

Comparison of Minerals in Swine, Oxen, and Fish.

	Swine.	Oxen.	Fish.
Potassium	0.9363	1.5200	1.7281
Sodium	0.5752	0.2695	0.5118
Iron	0.0218	0.1019	0.0300
Calcium	0.0298	0.0088	0.1138
Magnesium	0.1042	0.1006	0.0863
Phosphorus	0.7848	0.7090	1.0130
Chlorine	0.1787	0.2342	1.2447
Sulphur	0.7536	0.7719	1.1514
Water	72.8900	75.8000	80.6400

High Lime Content of Fish is Valuable.—"It will be noticed in Table No. 3 (taken from Katz, 1896) that fish, with respect to mineral constituents, is richer in calcium than other flesh foods. It is relatively low in iron because it does not retain hæmoglobin of the blood in the muscle, for example, as the flesh of the ox does.

Iodine in Fish.—"Although iodine probably exists in the living fish only in organic combination, it remains in the ash upon combustion and in this sense may be classified with the mineral substances present. Tressler gives the iodine content of fish (ocean) as being from 120 to 660 parts per billion."—*Taylor.*

(The foregoing figures have reference to the "edible" portions of fish.)

Importance of Mineral Matter in Fish-meal.—"The greatest value of fish-meal as a component of animal rationing lies in its mineral content. These minerals supply the essential material for maximum bone and gland growth in a form superior to that from any other source, since the minerals are in a form most readily absorbed by the animal. Not only are large healthy animals produced, but losses from sickness and death are reduced to a minimum. The protein component of fish-meal is of great value, being in a highly concentrated and readily absorbed form for supplementing the roughage low in protein content." *U.S. Bureau of Fisheries, Memo. S 288.*

TABLE NO. 4.—SUNDRY ANALYSES OF FISH-MEAL.

Mineral Matter in Fish-meal from Various Sources.

	Calcium Phosphate.	Protein.	Ether Extract.
Menhaden Meal (ordinary)	17.35	60.50	9.00
Menhaden Meal (extracted)	19.25	66.75	0.82
Sardine Meal (ordinary)	16.40	59.40	9.00
Sardine Meal (improved)	12.50	65.60	6.00
Norwegian Cod Meal (extracted)	25.90	55.00	1.50
English Market Waste Meal	16.40	60.00	4.50
Norwegian Herring Meal	8.95	65.00	11.00
Salmon Meal (steam-dried)	14.72	55.00	17.45
Salmon Meal (direct-heat dried)	23.33	53.50	9.64
British Columbia Pilchard	12.20	65.62	7.70
British Columbia Pilchard	15.12	66.06	5.44
British Columbia Dogfish	7.87	68.14	12.10

PART I.—DAIRY CATTLE.

Effect of Improved Transport on Source of Cattle-feeds.—"In the dairy industry during the past few decades developments of great economic importance have taken place in connection with both the production and distribution of milk. Formerly milk production was limited by the amount of cattle-food that could be grown on the farm or procured locally, and by far the greater part of the year's output of milk was obtained in the summer months, when pasture was plentiful. With the improvement of means of transport and the rise of food-refining industries, tropical products and commercial by-products have come to be used in increasing amounts as cattle-foods; and accompanying the use of these rich feeding-stuffs there has been a tendency to increase the production of milk, especially during the winter months, when the price of milk is high.—*Orr.*

Solids-not-fat in Milk and their Relative Importance.—Considering the nature of milk, it would be well to bear in mind that, whatever amount of milk a cow gives, she gives with the object of nourishing her offspring and not likely with the idea of providing man with a product which may be used for food and in the arts. If, then, the cow produces milk with the idea of nourishing her offspring, we should remember that the solids-not-fat take on an amount of importance far beyond that of the butter-fat. This is because the rate of growth of a calf is much more influenced by the solids-not-fat than by the amount or percentage of butter-fat in the milk. None of the compounds in the solids-not-fat can be considered as having more importance than any other part, for no single compound can perform its function without a certain very definite relative amount of every other compound. There must be just so much calcium and phosphorus, so much protein, and so much sugar, etc., before the normal rate of growth can be maintained.

Not all Problems are solved.—"These developments have raised new problems with regard to the feeding of cows. . . . Many of these problems are nutritional in character. On the side of production, there are problems concerning the economical use of concentrated feeding-stuffs to maintain a high milk yield, and with the adjustment of the ration to the requirements of the cow, so that a high yield may be maintained without damaging the constitution of the animal. . . . During the past few years, research in nutrition has increased our knowledge of the fundamental principles of the science, and though solutions to many of the problems referred to are not yet forthcoming, there is reason to hope that, within the next few years, more light will be thrown upon them by the investigations being carried out in this and in other countries.

NATURE OF MILK.

Composition of Milk is Best Guide in Feeding.—"There are very few problems connected with the dairy industry that are not associated with the nature and composition of milk (*see* Tables 6 and 7 on pages 14 and 15). With regard to feeding, it is clear that, as the cow must draw from the food all the materials to form milk, the composition of milk is an essential factor in determining the best ration for milk production. . . . Accordingly, the study of the composition and nature of milk should be the starting-point for the solution of many of the problems of the dairy industry. Yet, except for the percentage of butter-fat, little interest is taken in the subject by those engaged in the industry. To enable the questions discussed later to be better understood, a short account is given here of those constituents and qualities of milk which are of economic importance.

Nature of Milk Protein.—"Proteins or albuminoids consist chiefly of comparatively simple substances known as amino-acids linked together. There are about twenty different amino-acids and in most proteins all of them are represented. The amino-acids are like building-stones which nature uses in various proportions to build up the many different kinds of proteins which are formed by living bodies. Although all proteins contain the same units—the twenty or so different amino-acids—they may contain them in very different proportions. One protein may be very rich in one or two amino-acids which are poorly represented in, or,

in a few exceptional cases, may be entirely absent from, the make-up of another protein. In the process of digestion the animal body breaks down the proteins of the food to amino-acids, which are absorbed from the alimentary tract and used to build up the various kinds of proteins required in the different tissues.

Amino-acids in Milk Proteins compared with other Sources.—" In this way the body takes, for example, the proteins of oatmeal, breaks them down into amino-acids, and then uses such of these as it needs to build up the protein of muscle. It is obvious that if the proteins of oatmeal are of very different composition from the proteins of muscle, which as a matter of fact is the case, there will be a big wastage in transforming oatmeal proteins into muscle proteins, and, further, the digestive organs will require to deal with a lot of material which is of no use for constructive purposes. The point of importance with regard to milk proteins is that the proteins of the milk of any species contain amino-acids in exactly the proportions required by the young of that species to build up its muscles and other soft tissues, and they are present in a form that can be easily digested and assimilated by the young. No other food, except the egg, contains proteins especially adapted to the needs of the very young animal. Indeed, casein, the chief protein of milk, occurs nowhere else in nature.

Utilization of Proteins compared.—" The value for growth of the proteins of milk as compared with proteins from other sources has been tested by determining what proportions of the amounts eaten can be retained by the animal and used for tissue formation. The following figures from an experiment conducted by an American worker illustrate the nature of the results obtained when the proteins of milk were tested against those of two common foodstuffs. In this experiment the total energy value, or starch value, of the rations was approximately equal in each case. The animals experimented on were young pigs.

TABLE NO. 5.

Milk and Cereal Proteins compared.

Source of Protein.	Percentage of Protein in Ration.	Percentage of Protein retained in Body.
Milk	16	63
Oats	17	30
Wheat	18	25

" According to these figures, to form a given amount of body-tissue, the digestive organs of the growing animal must deal with more than twice as much of the proteins of oats or of wheat as of the proteins of milk.

Comparative Value of Milk and Animal Proteins.—" For growth purposes milk proteins are markedly superior to those from any other source. The only proteins that are comparable to milk proteins in their value for the formation of flesh and blood are those of flesh and blood themselves, and those, in the forms usually fed, are not so digestible as milk proteins. As will be seen later, the special value of milk proteins is a fact of economic importance."—*Dr. J. B. Orr, Aberdeen.*

TABLE NO. 6.—CONSTITUENTS OF MILK.

Chemical Analysis of Cow's Milk.

Proteins:	
Caseinogen Lactalbumin Lactoglobulin Fibrinogen Amino-acids Vitamins Enzymes	3.3 per cent.

Fats:

Butyrin, Caproin, Caprylin, Caprin — Glycerides of volatile acids.

Laurin, Myristin, Palmitin, Stearin, Olein — Glycerides of non-volatile acids.

Lipoids (Fat-like Substances):

Lecithin, Cholesterin, Probably other lipoids, Carotin (lipochrome) ..... 4.0 per cent.

Milk-sugar ..... 4.8 per cent.

Citric acid ..... 0.1 per cent.

Ash:

Sulphur, Phosphorus, Chlorine, Sodium, Potassium, Calcium, Magnesium, Iron, Iodine ..... 0.7 per cent.

Water ..... 87.1 per cent.

TABLE No. 7.

Chemical Analysis of Milk Proteins.

Proteins:

Amino-acids in Casein.		Amino-acids in Lactalbumin.
0.45	1. Glycine	0.37
1.85	2. Alanine	2.41
7.93	3. Valine	3.30
9.70	4. Leucine	14.03
7.63	5. Proline	3.76
4.10	8. Aspartic acid	9.30
21.77	9. Glutamic acid	12.89
3.88	7. Phenylalanine	1.25
6.50	12. Tyrosine	1.95
0.50	11. Serine	1.76
0.23	6. Oxyproline	.....
2.50	15. Histidine	2.61
3.81	14. Arginine	3.47
7.62	16. Lysine	9.87
2.20	17. Tryptophane	3.00
0.50	13. Cystine	1.73
1.61	18. Ammonia	1.31
3.00	19. And others	2.00

Chemical Analysis of Milk Minerals.

Ash—Minerals:

Calcium	0.120
Magnesium	0.012
Potassium	0.143
Sodium	0.051
Phosphorus	0.093
Chlorine	0.106
Sulphur	0.034
Iron	0.00024
Iodine	Trace

Average of Analyses of Milk.

Average Composition.

Constituent.	Usual Limits and Averages.		Convenient Approximation.
	Usual Limit of Variation.	Estimated Average.	
Fat	3.0–6.00	4.00	4.0
Protein	3.0–4.00	3.30	3.3
Carbohydrate	4.6–5.00	4.85	5.0
Ash	0.7–0.78	0.72	0.7
Solids-not-fat	8.5–9.50	8.90	9.0

Comparison of Milk from Different Breeds of Cows.

Composition of Milk of Different Breeds of Cattle.

Breed.	Total Solids.	Fat.	Solids-not-fat.
Jersey	14.87	5.19	9.68
Guernsey	14.69	5.16	9.53
Durham	13.38	4.05	9.33
Ayrshire	12.73	3.64	9.09
Holstein	11.96	3.43	8.53

MINERAL MATTER.

Mineral Content of Milk is adjusted to Requirements of Young.—" It has been shown that a supply of the proper amounts and proportions of all the essential mineral elements in the animal body is necessary for health and normal growth, and that most of the concentrated foodstuffs commonly used are deficient in one or more mineral elements. The mineral composition of a food is therefore one of the most important factors in deciding its value. In this respect milk is unique, because it is the only food which contains, in the proper proportions, all the minerals required by the suckling animal. The close relation between the composition of the mineral matter of milk, and the requirements of the young animal for these minerals, is shown when the ash of a young, rapidly growing animal is compared with the ash of the milk of its species. The following table (No. 8) gives the results of the analysis of the mineral matter contained in (*a*) the body of a young rabbit; (*b*) rabbit's milk; and (*c*) wheat.

TABLE No. 8.

Body of Rabbit, its Milk, and Wheat compared in Mineral Content.

	Rabbit 14 Days old.	Rabbit's Milk.	Wheat.
	Per Cent.	Per Cent.	Per Cent.
Phosphoric acid	41.9	39.9	47.2
Lime	35.0	35.7	3.3
Potash	10.8	10.1	31.2
Soda	6.0	7.9	3.1
Chlorine	4.9	5.4	0.3
Magnesium	2.2	2.2	12.1
Iron acids	0.2	0.1	1.3

Minerals in Cereals unsuited for Growth of Young.—"A comparison of the figures in the three columns shows that rabbit's milk contains exactly what is required to build up the young rabbit, whereas in wheat, which is a typical example of a cereal, the ratios of the essential minerals are totally different from those required for growth. Wheat shows a marked relative deficiency of lime, soda, and chlorine. These deficiencies are common to all cereals, and also to many other foodstuffs.

Different Mineral Requirement for Different Species.—"The mineral requirements of the young of different species vary slightly because there are differences in the composition of the ash of the milk of different species. Still, the differences are so small that there is a much closer correspondence between the composition of the mineral matter of milk from different species than between that of any milk and any other food. Consequently, in feeding a young animal, if milk of its own species is not available, the best substitute, as far as the supply of the necessary mineral matter is concerned, is the milk of another species."—*Orr.*

In another article by Orr on the importance of mineral matter for young, growing animals we find the following table:—

TABLE No. 9.—PROTEIN AND MINERAL COMPOSITION OF SOME FEEDING-STUFFS PER 100 PARTS.

Comparative Analysis of some Common Feeding-stuffs.

	Protein.	Total Ash.	Lime. (as CaO).	Phosphorus (as P_2O_5).
Animal products—				
Milk, cow's	3.50	0.74	0.17	0.22
Milk, sow's	7.25	1.09	0.41	0.35
Fish-meal	61.00	23.50	11.59	10.50
Grains and grain-offal—				
Corn	9.00	1.21	0.02	0.65
Middlings	16.00	4.63	0.15	2.25
Wheat	12.00	1.86	0.08	0.97
Oats	12.00	3.71	0.16	0.99
Fodder—				
Alfalfa-hay	15.00	6.89	1.58	0.54
Clover-hay	13.00	7.31	1.73	0.42
Timothy-hay	8.50	3.47	0.27	0.28
Oat-straw	2.50	4.40	0.36	0.18

"The animal products included in the above table contain all of the essential minerals in the proportions required for growth.

Use Mineral Content of Milk as Guide in compounding Rations.—"The milk of each species is exactly adjusted to the requirements of the young of that species. As these requirements vary according to the composition of the body and the rate of growth of different species, the percentage composition of the mineral matter of the milk varies. Thus the rapidly growing young pig receives a milk with a higher percentage of lime and phosphorus than the more slowly growing calf. The percentage of the different minerals in the milk of any species is an excellent guide to the composition of the mineral matter that should be aimed at in making up a ration for the young animals.

Minerals in Fish-meal are Good Substitute for Milk Minerals.—"Fish-meal, being made from bones and flesh, contains all the mineral matter in the proportion to form these. It will be seen that the ratio of lime to phosphorus in fish-meal is not unlike that in sow's or cow's milk. The percentages, however, are so high that comparatively small amounts of fish-meal added to a ration yield a sufficient supply of these."—*Orr.*

Mineral Matter in Cereals proven Inadequate for Growth.—"Hart and McCollum, with their co-workers, in the course of their valuable work on deficiencies of the different grains, have shown that the deficiency of grains in mineral matter is so great that a diet consisting exclusively of grains will not support growth, even though any other deficiencies that may be present are made good. . . . They indicate that three factors may be involved in the production of the disease (rickets)—namely, (1) deficiency of mineral matter, (2) deficiency of fat-soluble A, and (3) toxicity of wheat products. In our experiments the condition did not occur when the amount and ratios of the different inorganic constituents were adjusted, and we are inclined to believe that the frequently noted toxic influence of wheat-offal is due to the composition of its ash, which, with other deficiencies, shows a marked excess of phosphorus to calcium."—*Elliott, Crichton, and Orr, Rowett Research Institute.*

PROBLEMS OF FEEDING (ANIMALS IN MILK).

Constancy of Milk Constituents.—"Though the percentage of the various constituents of milk may vary a little in different cows, or in the same cow at different stages of lactation, the composition of the constituents remains practically constant. Thus, no matter what kinds of proteins are given in the food, the milk secreted always contains casein and lactalbumin; and in spite of the wide variation in the proportion of essential minerals in different foodstuffs, the proportions of them in milk vary very little.

Necessity for supplying all Constituents of Milk in Daily Ration.—"The fact that milk is a standard product has an important bearing on feeding problems. The materials used to build up the constituents of milk must be derived ultimately from the food. The substances present in food, therefore, are of value for milk production only to the extent that they yield these materials in a digestible form. This rather obvious principle is not taken sufficiently into account in the recognized systems of estimating the value of foods and compounding rations. The usual feeding standards for milk cows are expressed in terms of 'food units' (or 'starch values') and 'nutritive ratios' (i.e., the proportion of protein to the other energy-yielding constituents of the ration). This method, though of a certain value, does not touch the most difficult problem in feeding. It would be possible to satisfy the food requirements of the cow with starch or some other carbohydrate, and to supply the protein with some protein like (the zein of) corn, which is deficient in two of the amino-acids which are necessary to build up milk protein. Such a ration, though meeting the requirements of the conventional feeding standards, would be useless for milk production, because it would neither contain the elements necessary for the formation of milk protein, nor yield the minerals necessary for milk. Of course, such an extreme case would not occur in practice. But the example shows that to satisfy the requirements of a feeding standard does not necessarily imply that the requirements of the cow for the production of milk are satisfied.

Constituents of Milk are Guide in compounding Rations.—"The proper way to approach the problem is to consider all the substances required for milk formation, and to try to arrange a ration such that, on digestion, these various substances will be absorbed from the intestine, and will be available in the amounts and proportions required to replace those carried off in the milk.

More Care required in compounding Ration for High-producing Cows.—"In the case of cows giving only 300 or 400 gallons of milk a year, which is probably as much as nature intended them to give, and using the natural diet got when grazing on good mixed pasture, supplemented in winter by such foods as hay, roots, and cereal grains, the question of the exact composition of the ration is not so important, because, in the amount of such food that the cow will eat, there is likely to be a sufficiency of all the constructive materials required to yield 300 or 400 gallons of milk. But under conditions of intensive milk production, where cows are fed with highly concentrated feeding-stuffs and commercial by-products, which were not intended by nature as food for a lactating ruminant, and the milk yield is five or six times the amount nature meant the cow to give, it is necessary to inquire whether all the materials required for the formation of that quantity of milk are being supplied in the food.

High Production is not Basis for deciding Quality of Ration.—"The fact that a large amount of milk is being produced on a given ration is no guarantee that the ration is satisfactory. As long as a cow with a high capacity to yield milk is given a rich ration, she will continue, for a time, to give milk, even though the ration is deficient in certain constituents. The deficiency is made good with materials taken from the cow's own tissues, and, until these are depleted, milk formation will proceed. The depletion of the tissues may, however, as will be seen later, be disastrous to the health of the cow and to milk production in a subsequent lactation, unless the depleted tissues have an opportunity to refill during an intervening dry period.

Other Factors which determine Value of a Ration.—"Although the milk yield itself and the health of the cow are the most interesting points in the problem of the properly balanced ration, the cost of food per gallon of milk produced is also of importance. Any of the substances required in the formation of milk may be the limiting factor in its production. On an ill-balanced ration, therefore, the yield may be limited by the deficiency of one or more essential elements, which the tissues of the cow cannot supply indefinitely. On the other hand, there may be an excess of certain constituents which cannot be used. The most economical food is, therefore, that which contains the right amounts and proportions of all the constituents. This ration has no deficiency to limit production and no excess to be wasted. Unfortunately, this ideal ration has not yet been devised, though there is reason to believe that the information which will allow us to get nearer to it is gradually accumulating. The fact that not only research workers, but also practical feeders, are beginning to understand the nature and importance of the problem is a significant forward step.

"In the milk cow's ration the constituents which are most likely to be deficient are proteins, mineral matter, the unknown 'vitamins,' and water."—*Orr.*

MINERAL REQUIREMENTS OF THE DAIRY COW.

Mineral Content of Ration Most Important Part.—"The mineral requirements of the dairy cow have received comparatively little attention in this country. It has been too readily assumed that any ration that supplied a sufficient amount of total protein, and had the requisite number of 'food units,' would contain sufficient of all the minerals essential to milk formation. While this may be so in the case of cows with low milk yield, the results of recent experiments have shown that, in the modern cow with a high milk yield, the difficulty of replacing the minerals given out in the milk is probably the most important of all problems connected with the feeding of dairy cows.

Minerals required by Dairy Cow other than for Milk Production.—"The lactating animal has a double requirement for minerals. The amounts lost in the urine and fæces, from the ordinary wear and tear of tissues, apart from milk production, must be replaced. In addition, a supply is required for milk production. The first of these, the maintenance requirement, has not been accurately determined, but, according to the estimation of Henneberg, a cow needs about 1½ oz. of lime and about ⅘ oz. of phosphoric acid per day. The amounts required for milk production depend, of course, upon the yield. A cow giving 5 gallons of milk per day loses from her body the following amounts, in ounces, of those minerals which occur in largest amounts in milk, namely:—

Minerals in Five Gallons of Milk.

	Oz.		Oz.
Lime (CaO)	1.3	Phosphorus (P_2O_5)	1.6
Magnesium (MgO)	0.1	Potash (K_2O)	1.3
Sodium (Na_2O)	0.5	Chlorine (Cl)	0.8

Retention and Loss of Minerals.—"But in most cases the whole of the mineral matter in the food cannot be assimilated and retained. Weiske has estimated that the food should contain about three times the amount of lime that the animal requires to assimilate. As a matter of fact, we now know that the proportion of any mineral fed that can be assimilated varies according to the composition and nature of the rest of the ration. All that can be said, therefore, is that the ration should contain a margin in excess of the amount which the body requires. In the case of lime and phosphorus, for example, according to the foregoing figures, a cow giving 5 gallons of milk per day should receive in her food an amount of lime greater than 2.8 oz., and of phosphorus greater than 2.4 oz. (reckoned as P_2O_5). How much greater than these amounts the supply in the food should be we are unable to state definitely.

Minerals deficient in Winter Rations.—"Not only are certain minerals liable to be deficient in winter rations, but it is believed that the minerals are present in forms in which they are less easily assimilated than is the case with pasture. It is chiefly in winter feeding, therefore, that the question of the mineral requirements of the milk cow demands special attention."—*Orr.*

Addition of Minerals to Ration not Solution of Problem.—"It is possible to add minerals to the ration, and so ensure that there will be an ample supply in the food. Unfortunately, however, the problem cannot be so easily solved, for there seems to be a number of factors that make assimilation of certain minerals difficult, even when an abundance is present in the food.

Addition of Fish-meal to Ration is Advantageous.—"Although so very little definite knowledge is available with regard to this all-important subject of the mineral balance in milk cows, it is even now possible to make some suggestions which might be of practical value. Attention should be paid to the mineral content of the ration of stall-fed cows. The calcium-supply, which is deficient in most feeds, can be augmented by the addition of chalk and steamed-bone flour. The probable deficiencies of sodium and chlorine can be made good by the use of a salt brick fixed in the stall, so that the animal can satisfy its own needs at will. The amounts of minerals that should be added will, of course, depend on the nature of the concentrates used. For example, corn, which is very poor in both calcium and phosphorus, would need a supply of both, whereas a ration with *fish-meal, which is rich in those minerals,* might require neither."

FISH-MEAL FOR DAIRY CATTLE.

Use of Fish-meal for Dairy Cows at Dominion Experimental Farm, Ottawa, Ontario.—"This feed may be given to beef or dairy cattle up to 2 lb. daily per 1,000 lb. live weight, but the animals must be accustomed to it very gradually. Many European and American investigators report its value in milk production, showing its superiority over an

PURE-BRED AYRSHIRE COW.

Name, Picken's Patty (Imp.) (16212) ; born, January 17th, 1927 ; sire, Stannock Endeavor (24690) ; dam, Picken's Melody (16204) ; owner, Consolidated Mining and Smelting Co., Trail, B.C.

PURE-BRED AYRSHIRE COW.

Name, Kilfillan June Blossom (Imp.) (11596) ; born, March 17th, 1927 ; sire, Cowhill Dictator (24526) ; dam, Kilfillan Celery (A 8016) ; owner, Consolidated Mining & Smelting Co., Trail, B.C.

equal weight of cottonseed and linseed-oil meal in milk produced and that no flavours were imparted to the milk or fat.

"At the Experimental Farm, Ottawa, Ont., in 1916, an experiment was conducted comparing fish-meal with other concentrates in the production of milk. In this trial 'Grimsby brand' fish-meal was used, and after the first few feeds it was eaten with increasing relish and the appetite of the animals increased perceptibly.

Composition of Grain Ration.—"For this work the basis of the meal mixture throughout the experiment was a mixture of wheat-bran 400 lb., gluten feed 200 lb., ground oats 200 lb. The additions to this basic meal ration during the various periods were: (1) Fish-meal, 10 per cent. addition; (2) gluten feed, 24 per cent. addition; (3) cottonseed-meal, 15 per cent. addition; (4) linseed-oil meal, 21 per cent. addition; and (5) peanut-oil meal, 13 per cent. addition.

Results obtained at Ottawa.—"The results of this trial, in brief, are as follow: Compared with gluten feed (23 per cent. protein), fish-meal required 1.1 lb. meal mixture less per 100 lb. milk produced and 39 lb. meal mixture less per 100 lb. fat produced. The cows increased in production on fish-meal and dropped very perceptibly when again placed on gluten. A very noticeable feature was the greatly stimulated appetites and the increased weights of all cows when on fish-meal.

Dairy Cows always gain in Weight when fed Fish-meal.—"During this trial the cows made a most noticeable gain in weight on fish-meal—namely, 37 lb. per animal in fourteen days—and at the same time more than maintaining a normal milk-flow. Judging from this, a good brand of fish-meal should be excellently suited to the feeding of beef animals."—*Archibald.*

In a personal letter to the editor, Mr. William Forrest, Superintendent of the Consolidated Company Farm at Trail, has this to say regarding fish-meal:—

"We are using 8 per cent. pilchard fish-meal in our mixture, and find it very satisfactory.

"We are using fish-meal for everything except our horses, and find the chickens and hogs are doing even better on it than the milch cows, which have responded well."

METHODS OF FEEDING FISH-MEAL TO DAIRY COWS.

Cows fed Fish-meal are Better Satisfied.—We have just received the following letter, dated July 20th, 1930, from Mr. L. O. Forde, who is a prominent dairyman in the Chilliwack Valley:—

"Dear Sir,—Dixon* tells me you wanted to get some particulars *re* feeding fish-meal. I have been feeding it now for over a year and I prefer it to oil-cake meal. Cows appear to be better satisfied; this is especially noticeable in early spring before grass comes. I feed 1 lb. a day in winter and this time of year ¼ lb. per cow. When I started to feed fish-meal I was very careful to mix thoroughly and feed a very small quantity; now I just throw it in on top of their meal and all my cows lick it up clean. Trusting this will give you the desired information, I remain, Yours sincerely, L. O. Forde."

No Craving when fed Fish-meal.—In further explanation of Mr. Forde's remark regarding the effect of fish-meal on his cows in early spring, we would add that it is something like this: Many dairymen have noticed that their cows become fretful and restless along towards spring; they appear to be craving something that they expect to get when put on pasture; that is, they do if they have not been fed fish-meal throughout the winter. This craving is probably for something that was lacking in the ration. Fish-meal therefore appears to supplement ordinary hay, silage, and grain rations with those things which are known to be lacking in such feeding-stuffs. It is also particularly interesting to note that Mr. Forde was one of the very first dairymen in the Chilliwack Valley to adopt fish-meal as a protein concentrate for dairy cows.

* The Dixon referred to is Mr. A. S. Dixon, Supervisor, Chilliwack Cow-testing Association.

Exercise Care when feeding Fish-meal to Cows.—We offer the following letter from Mr. H. Bose, Surrey Centre, B.C., for your consideration, as it contains some views divergent to Mr. Forde's:—

"Dear Sir,—*Re* fish-meal. I have been requested by Mr. Clarke, our Tester, to write you as to results obtained by feeding fish-meal. We use fish-meal in the poultry ration all the time with good results. We also feed some to the dairy cows during the winter. It is safe to feed up to 1 lb. a day per cow with good results; when we feed more we seem to have constipation, which is an undesirable condition in a dairy herd. Great care has to be taken in the feeding, as the fish-meal is so finely ground that it penetrates the feeder's clothes; and it seems that the feeder has to change his outer clothes before he starts milking, as a very little of the meal getting into the milk will cause a complaint from the dairy. There is not any doubt but that fish-meal can be fed to poultry and dairy cattle as a cheap source of protein. I remain, Yours respectfully, H. Bose."

Advantage to feed Fish-meal carefully.—The foregoing letters are from dairymen who are well known in their respective districts and their opinions are well worth while considering. On the one hand it is stated that "I just throw it in on top of their meal," while, on the other hand, it is advised that considerable care be taken in handling the fish-meal on account of the liability of tainting milk from direct contact—which is the only way fish-meal has ever been known to taint milk. If the feeding of fish-meal necessitates sanitary precautions in the dairy-barn it will have brought about a condition much to be desired in all dairy-barns. Fish-meal coming in direct contact with warm milk would give undeniable notice of its presence, whereas other products which are sometimes fed to dairy cows are not so easily detected and precautions against their contamination of milk may not, therefore, be so readily adopted.

Early User of Fish-meal in B.C.—Though Mr. Bose does not mention it in his letter, we know that he first started to feed fish-meal to his cows on March 4th, 1929, which gives him the honour of initiating the practice in the Fraser Valley. We also recollect that most of his cows were fall-freshened, and that therefore the March cream cheque would rightfully have been slightly smaller than the February cheque—but it was more.

COMPARISON OF LINSEED-MEAL *VERSUS* EDIBLE FISH-MEAL.

(Dominion Experimental Farm, Project A. 648, Agassiz, B.C.)

Considerable quantities of edible fish-meal are being fed in the Fraser Valley, not only to poultry and hogs, but also to dairy cattle. Due to this fact, it was decided to commence feeding it at this station, and when possible make some comparisons with other protein feeds. The following rations were fed to nine cows over a period of six weeks:—

Corn silage, 50 lb. per cow per day.
Pulped mangels, 40 lb. per cow per day.
Mixed clover-hay, 5 lb. per cow per day.
Meal mixture, 12 lb. per cow per day.

The meal mixture used was made up of:—

300 lb. of bran at $36.50 per ton.
30 lb. of ground oats at $40 per ton.
100 lb. of corn-meal at $53 per ton.

Fish-meal in the Dairy Ration at Agassiz, B.C.—During the first and third two-week periods of the trial, 50 lb. of fish-meal, costing $81 per ton, were added to this grain ration, and during the second period, for comparison, 100 lb. of oil-meal at $65 per ton were substituted.

PURE-BRED HOLSTEIN BULL.

Name, Strathmore Sylvius Pietje (70839); born, July 10th, 1926; sire, Matchless Sylvius (48759); dam, Strathmore Canary Pietje (61140); record of dam, 16,925 lb. milk as 2-yr.-old (in R.O.P.); owner, William Weaver, Natal, B.C.

Mr. Weaver feeds fish-meal to his entire herd of dairy cows.

No analysis of the oil-meal or fish-meal was made, but the guaranteed analysis as shown on the tags was as follows:—

	Oil-cake Meal.	Fish-meal.
	Per Cent.	Per Cent.
Protein	35	70
Fat	7	8
Fibre	Max. 8	None

One Pound of Fish-meal equals Two Pounds of Linseed-meal.—All milk produced by the cows was weighed and sampled for butter-fat test. The second week in each period only was used for computation of data, the first week being allowed for transition from one ration to another.

The following are the data obtained:—

FISH-MEAL VERSUS LINSEED-MEAL.

Experimental Ration.		1. Fish-meal.	2. Linseed-meal.	3. Fish-meal.	Average of 1 and 3, Fish-meal.
Number of cows in experiment		9	9	9	9
Duration of test	days	7	7	7	7
Milk produced in 7 days	lb.	2,252.6	2,244.1	2,231.9	2,242.25
Average per cent. of fat	%	3.52	3.51	3.42	3.47
Fat produced in 7 days	lb.	79.3172	78.7320	76.4398	77.8785
Hay consumed at $12 per ton	„	315	315	315	315
Silage consumed at $5 per ton	„	3,150	3,150	3,150	3,150
Mangels consumed at $5 per ton	„	2,520	2,520	2,520	2,520
Meal consumed at 2.0107c. per pound	„	706	668	706	706
Linseed-meal consumed at 3.25c. per pound	„	.....	88	.....	.....
Fish-meal consumed at 4.05c. per pound	„	50	.....	50	50
Total cost of feed	$	30.2855	32.3565	32.2855	32.2855
Feed cost to produce 100 lb. milk	$	1.43¾	1.4418	1.4465	1.43989
Feed cost to produce 100 lb. fat	$	40.7042	41.09701	42.2365	41.4703
Profit over feed with fat at 50c. per pound	$	7.3731	7.0095	5.9344	6.6537

From the foregoing data it will be observed that the results were about equal. The nine cows in seven days produced less than 2 lb. more milk when being fed the linseed-meal ration. The test showed slightly higher at this time. When weather conditions are considered along with the very close margin of difference in results, it is safe to assume that, with rations compounded as above, 1 lb. of fish-meal could replace 2 lb. of linseed-meal in a dairy-cattle ration without seriously interfering with the milk-flow.—*Experimental Farm, Agassiz, B.C., 1929 Annual Report.*

Dairymen's Claims substantiated.—Further comment on this project (A. 648) which was conducted at the Dominion Experimental Farm, Agassiz, B.C., is hardly necessary as the results obtained are conclusive. They also substantiate claims made by individual farmers throughout the Fraser Valley section of British Columbia. In this project the cows were not weighed either before or after the test, but it is fairly safe to say that, even though the test was of short duration, there would have been an increase in the body-weight of the cows fed fish-meal, as this is usually the first thing which a new user of fish-meal notices—the body-weight increases while the milk-flow continues at the usual level, or sometimes increases.

Value of Balanced Ration demonstrated.—A feature of the ration fed the cows in this project is very well worth noting—the protein requirements of these cows was exactly

met. If more dairymen would give as much attention to the protein requirement of their cows as was evidently done in this project the cost of milk production would undoubtedly be lowered. Calculating the protein requirement of a cow is made easy by Tables Nos. 11 to 13D on pages 25 and 26 of this bulletin.

COMPOUNDING A GRAIN MIXTURE.

Grain Mixture should be suited to Roughages fed.—A few simple rules for making up a grain mixture are given briefly below.

(1.) Make up the mixture to fit the roughage available. With roughage entirely of the low-protein class the grain should contain approximately from 18 to 22 per cent. of protein, while with exclusively high-protein roughage the grain ration need contain only about 13 to 16 per cent.

(2.) Select grains that will furnish the various constituents, especially protein, at the least cost, using home-grown grains if possible.

(3.) Be sure that the mixture is light and bulky.

(4.) The mixture should be palatable.

(5.) See that the grain has the proper physiological effect upon the cow.

All these suggestions should be kept in mind in order to obtain the best possible combination of grains. For the convenience of the feeder, Table No. 10, showing the digestible protein content of the more common grains and by-products feeds, is given. The per cent. columns are arranged in 5 per cent. divisions.

TABLE NO. 10.—APPROXIMATE DIGESTIBLE PROTEIN CONTENT OF VARIOUS GRAINS AND BY-PRODUCTS.

Common Feeding-stuffs arranged by Average Analysis.

Average 5 per Cent. (2.5 to 7.4 per Cent.).	Average 10 per Cent. (7.5 to 12.4 per Cent.).	Average 15 per Cent. (12.5 to 17.4 per Cent.).	Average 20 per Cent. (17.5 to 22.4 per Cent.).
Corn-meal. Corn-and-cob meal. Hominy feed. Dried beet-pulp.	Wheat, ground. Oats, ground. Barley, ground. Rye, ground. Buckwheat, ground.	Wheat-bran. Wheat middlings. Dried distiller's grains (rye).	Gluten feed. Malt sprouts. Dried brewer's grains. Dried distiller's grains (corn). Cocoanut-meal. Peanut-meal with hulls. Cow-peas.

Average 25 per Cent. (22.5 to 27 per Cent.).	Average 30 per Cent. (27.5 to 32.4 per Cent.).	Average 35 per Cent. (32.5 to 37.4 per Cent.).	Average 40 per Cent. (37.5 to 42.4 per Cent.).
Buckwheat middlings.	Gluten-meal. Linseed-meal. Soy-beans.	Cottonseed-meal.	Peanut-meal (hulled nuts).

How to find Percentage of Protein in Grain Mixture.—The per cent. of protein in a grain mixture may be found as follows: Take any number of parts of any number of feeds in the table, and for each part put down the per cent. of the column in which it is found. Add these numbers and divide the sum by the number of parts. Examples:—

1 part wheat-bran	15
1 part cottonseed-meal	35
1 part gluten feed	20
	70 divided by 3 equals 23.3 per cent. protein.
3 parts wheat-bran (3 by 15)	45
2 parts cottonseed-meal (2 by 35)	70
1 part gluten feed (1 by 20)	20
	135 divided by 6 equals 22.5 per cent. protein.

(From Farmers' Bulletin 743, U.S. Dept. of Agriculture.)

Protein Requirement of Dairy Cows.—"The protein requirements of dairy cows have received a good deal of attention. Feeding standards fix the *quantity* of protein to be fed, and the estimate is usually a generous one. But the standards take no account of the *quality* of the protein. We have already seen that different proteins vary widely in the proportions in which different amino-acids enter into their composition, and it is therefore obvious that some will be of more value for conversion into milk proteins than others." (*See* Table No. 2, which gives the comparative values of various proteins.)

Calculation of the amount of protein required by a dairy cow in twenty-four hours is easily possible by reference to the following table:—

TABLE NO. 11.—DAILY MAINTENANCE REQUIREMENTS FOR DAIRY COWS.

Weight in Pounds (of the Cow).	Digestible Crude Protein.	Total Digestible Nutrients.	Weight in Pounds (of the Cow).	Digestible Crude Protein.	Total Digestible Nutrients.
	Lb.	Lb.		Lb.	Lb.
800	0.560	6.340	1,200	0.840	9.500
850	0.595	6.725	1,250	0.875	9.895
900	0.630	7.132	1,300	0.910	10.302
950	0.665	7.517	1,350	0.945	10.687
1,000	0.700	7.925	1,400	0.980	11.095
1,050	0.735	8.310	1,450	1.015	11.480
1,100	0.770	8.717	1,500	1.055	11.887
1,150	0.805	9.102			

Protein Requirement for Milk, in Addition to Requirement for Maintenance.—In addition to the above amounts which are required for maintenance only, the dairy cow will require an additional amount of protein in proportion to the amount and quality of milk which she gives. The following table gives the amounts required in twenty-four hours, according to Haecker's standard:—

TABLE NO. 12.

	Digestible Crude Protein. Lb.
For each pound of 3.0 per cent. milk	0.047
For each pound of 3.5 per cent. milk	0.049
For each pound of 4.0 per cent. milk	0.054
For each pound of 4.5 per cent. milk	0.057
For each pound of 5.0 per cent. milk	0.060
For each pound of 5.5 per cent. milk	0.064
For each pound of 6.0 per cent. milk	0.067

For quicker reference, the following tables should be consulted:—

TABLE NO. 13.—REQUIREMENTS FOR PRODUCING 3.5 PER CENT. MILK.

	Digestible Crude Protein.	Total Digestible Nutrients.
	Lb.	Lb.
20 lb. milk	0.980–1.220	5.680– 6.320
30 lb. milk	1.470–1.830	8.520– 9.480
40 lb. milk	1.960–2.440	11.360–12.640
50 lb. milk	2.450–3.040	14.200–15.800
60 lb. milk	2.940–3.660	17.040–18.960

TABLE NO. 13A.—REQUIREMENTS FOR PRODUCING 4 PER CENT. MILK.

	Digestible Crude Protein.	Total Digestible Nutrients.
	Lb.	Lb.
20 lb. milk	1.080–1.300	6.220– 6.920
30 lb. milk	1.620–1.950	9.330–10.380
40 lb. milk	2.160–2.600	12.440–13.840
50 lb. milk	2.700–3.250	15.550–17.300
60 lb. milk	3.240–3.900	18.660–20.760

TABLE NO. 13B.—REQUIREMENTS FOR PRODUCING 4.5 PER CENT. MILK.

	Digestible Crude Protein.	Total Digestible Nutrients.
	Lb.	Lb.
15 lb. milk	0.855–1.035	5.070– 5.640
20 lb. milk	1.140–1.380	6.760– 7.520
30 lb. milk	1.170–2.070	10.140–11.280
40 lb. milk	2.280–2.760	13.520–15.040
50 lb. milk	2.850–3.450	16.900–18.800

TABLE NO. 13C.—REQUIREMENTS FOR PRODUCING 5 PER CENT. MILK.

	Digestible Crude Protein.	Total Digestible Nutrients.
	Lb.	Lb.
15 lb. milk	0.900–1.095	5.430– 6.030
20 lb. milk	1.200–1.460	7.240– 8.040
30 lb. milk	1.800–2.190	10.860–12.060
40 lb. milk	2.400–2.920	14.480–16.080
50 lb. milk	3.000–3.650	18.100–20.100

TABLE NO. 13D.—REQUIREMENTS FOR PRODUCING 5.5 PER CENT. MILK.

	Digestible Crude Protein.	Total Digestible Nutrients.
	Lb.	Lb.
15 lb. milk	0.960–1.155	5.775– 6.420
20 lb. milk	1.280–1.540	7.700– 8.560
30 lb. milk	1.920–2.310	11.550–12.840
40 lb. milk	2.560–3.080	15.400–17.120
50 lb. milk	3.200–3.850	19.250–21.400

Using the Tables to calculate a Ration.

Example: A 1,000-lb. cow giving 30 lb. 4 per cent. milk.

Requirements for Maintenance.

Digestible Crude Protein. Lb.		Total Digestible Nutrients. Lb.
0.700		7.925
	(For 30 lb. 4 per cent. milk.)	
1.620		9.330
2.320		17.255

The following ration would provide the amount and kind of food required:—

	Digestible Crude Protein.	Total Digestible Nutrients.
	Lb.	Lb.
8 lb. mixed hay	0.320	3.700
40 lb. corn silage	0.400	7.200
8 lb. oat-chop	0.780	5.630
1½ lb. pilchard-meal	0.904	1.040
	2.404	17.570
Amount required	2.320	17.255
Amount fed	2.404	17.570

It is advisable to slightly overfeed, as in this instance, than to underfeed.

Table No. 14.—British Columbia Pilchard-meal.

Average Analysis.

	Per Cent.
Moisture	6.80
Oil	7.70
Nitrogen	10.50
Protein	65.62
Phosphoric acid	5.60
Bone phosphate	12.20

Feeding Value of Various Amounts of Pilchard-meal.

	Digestible Crude Protein. Lb.	Total Digestible Nutrients. Lb.
¼ lb.	0.151	0.173
½ lb.	0.301	0.347
¾ lb.	0.452	0.519
1 lb.	0.603	0.693
2 lb.	1.206	1.386
3 lb.	1.809	2.079
4 lb.	2.412	2.772
5 lb.	3.015	3.465
6 lb.	3.618	4.158
7 lb.	4.221	4.851
8 lb.	4.824	5.544
9 lb.	5.427	6.237
10 lb.	6.037	6.930

Table No. 15.

(University of Wisconsin Special Circular, May, 1923.)

Computing Rations is simplified by Use of these Tables.

Barley.				Beet-pulp, Dried.		
Dry Matter.	Digestible Crude Protein.	Total Digestible Nutrients.	Amount.	Dry Matter.	Digestible Crude Protein.	Total Digestible Nutrients.
Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
0.23	0.02	0.20	0.25	0.23	0.01	0.18
0.45	0.04	0.40	0.50	0.46	0.02	0.36
0.68	0.07	0.60	0.75	0.69	0.03	0.54
0.91	0.09	0.79	1.00	0.92	0.05	0.72
1.81	0.18	1.59	2.00	1.84	0.09	1.43
2.72	0.27	2.38	3.00	2.75	0.14	2.15
3.63	0.36	3.18	4.00	3.67	0.18	2.86
4.54	0.45	3.97	5.00	4.59	0.23	3.58
5.44	0.54	4.76	6.00	5.51	0.28	4.30
6.35	0.63	5.56	7.00	6.43	0.32	5.01
7.26	0.72	6.35	8.00	7.34	0.37	5.73
8.16	0.81	7.15	9.00	8.26	0.41	6.44
9.10	0.90	7.90	10.00	9.20	0.50	7.20
Corn, Dent.				Oats.		
0.22	0.02	0.21	0.25	0.23	0.02	0.18
0.45	0.04	0.43	0.50	0.45	0.05	0.35
0.67	0.06	0.64	0.75	0.68	0.07	0.53
0.90	0.08	0.86	1.00	0.91	0.10	0.70
1.79	0.15	1.71	2.00	1.82	0.19	1.41
2.68	0.22	2.57	3.00	2.72	0.29	2.11
3.58	0.30	3.43	4.00	3.63	0.39	2.82
4.48	0.38	4.28	5 00	4.54	0.48	3.52
5.37	0.45	5.14	6.00	5.45	0.58	4.22
6.26	0.52	6.00	7.00	6.36	0.68	4.93
7.16	0.60	6.86	8.00	7.26	0.78	5.63
8.06	0.68	7.71	9.00	8.17	0.87	6.34
9.00	0.80	8.60	10.00	9.10	1.00	7.00
Rye.				Bran, Wheat.		
0.23	0.02	0.20	0.25	0.22	0.03	0.15
0.45	0.05	0.40	0.50	0.45	0.06	0.30
0.68	0.07	0.61	0.75	0.67	0.09	0.46
0.91	0.10	0.81	1.00	0.90	0.12	0.61
1.81	0.20	1.62	2.00	1.80	0.25	1.22
2.72	0.30	2.43	3.00	2.70	0.38	1.83
3.62	0.40	3.24	4.00	3.60	0.50	2.44
4.53	0.50	4.05	5.00	4.50	0.62	3.04
5.44	0.59	4.86	6.00	5.39	0.75	3.65
6.34	0.69	5.67	7.00	6.29	0.88	4.26
7.25	0.79	6.48	8.00	7.19	1.00	4.87
8.15	0.89	7.29	9.00	8.09	1.12	5.48
9.10	1.00	8.10	10.00	9.00	1.20	6.10

TABLE No. 15—*Continued.*

MIDDLINGS, WHEAT, STANDARD.				BREWER'S GRAINS, DRIED.		
Dry Matter.	Digestible Crude Protein.	Total Digestible Nutrients.	Amount.	Dry Matter.	Digestible Crude Protein.	Total Digestible Nutrients.
Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
0.22	0.03	0.17	0.25	0.23	0.05	0.16
0.45	0.07	0.35	0.50	0.46	0.11	0.33
0.67	0.10	0.52	0.75	0.69	0.16	0.49
0.90	0.13	0.69	1.00	0.92	0.22	0.66
1.79	0.27	1.39	2.00	1.85	0.43	1.31
2.68	0.40	2.08	3.00	2.78	0.64	1.97
3.58	0.54	2.77	4.00	3.70	0.86	2.63
4.48	0.67	3.46	5.00	4.62	1.08	3.28
5.37	0.80	4.16	6.00	5.55	1.29	3.94
6.26	0.94	4.85	7.00	6.48	1.50	4.60
7.16	1.07	5.54	8.00	7.40	1.72	5.26
8.06	1.21	6.24	9.00	8.32	1.94	5.91
9.00	1.30	6.90	10.00	9.20	2.20	6.60
DISTILLER'S GRAINS, DRIED, FROM CORN.				GLUTEN FEED.		
0.23	0.05	0.22	0.25	0.23	0.05	0.20
0.47	0.11	0.44	0.50	0.46	0.11	0.40
0.70	0.17	0.67	0.75	0.68	0.16	0.60
0.93	0.22	0.89	1.00	0.91	0.22	0.81
1.87	0.45	1.78	2.00	1.83	0.43	1.61
2.80	0.67	2.67	3.00	2.74	0.65	2.42
3.74	0.90	3.56	4.00	3.65	0.86	3.23
4.67	1.12	4.44	5.00	4.57	1.08	4.04
5.60	1.34	5.33	6.00	5.48	1.30	4.84
6.54	1.57	6.22	7.00	6.39	1.51	5.65
7.47	1.79	7.11	8.00	7.30	1.73	6.46
8.41	2.02	8.00	9.00	8.22	1.94	7.26
9.30	2.20	8.90	10.00	9.10	2.20	8.10
COTTONSEED-MEAL, CHOICE.				LINSEED-MEAL, OLD PROCESS.		
0.23	0.09	0.20	0.25	0.23	0.08	0.19
0.46	0.18	0.39	0.50	0.45	0.15	0.39
0.69	0.28	0.59	0.75	0.68	0.23	0.58
0.92	0.37	0.78	1.00	0.91	0.30	0.78
1.85	0.74	1.56	2.00	1.82	0.60	1.56
2.78	1.11	2.35	3.00	2.73	0.91	2.34
3.70	1.48	3.13	4.00	3.64	1.21	3.12
4.62	1.85	3.91	5.00	4.54	1.51	3.90
5.55	2.22	4.69	6.00	5.45	1.81	4.67
6.48	2.59	5.47	7.00	6.36	2.11	5.45
7.40	2.96	6.26	8.00	7.27	2.42	6.23
8.32	3.33	7.04	9.00	8.18	2.72	7.01
9.20	3.70	7.80	10.00	9.10	3.00	7.80

TABLE No. 15—*Continued.*

Soy-bean Oil Meal.				Alfalfa-hay.		
Dry Matter.	Digestible Crude Protein.	Total Digestible Nutrients.	Amount.	Dry Matter.	Digestible Crude Protein.	Total Digestible Nutrients.
Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
0.22	0.10	0.21	0.25	.....	.....	.....
0.45	0.20	0.42	0.50	.....	.....	.....
0.67	0.30	0.63	0.75	.....	.....	.....
0.90	0.40	0.84	1.00	0.91	0.11	0.52
1.79	0.79	1.69	2.00	1.83	0.21	1.03
2.68	1.19	2.54	3.00	2.74	0.32	1.55
3.58	1.59	3.38	4.00	3.66	0.42	2.06
4.48	1.98	4.22	5.00	4.57	0.53	2.58
5.37	2.38	5.07	6.00	5.48	0.64	3.10
6.26	2.78	5.92	7.00	6.40	0.74	3.61
7.16	3.18	6.76	8.00	7.31	0.85	4.13
8.06	3.57	7.60	9.00	8.23	0.95	4.64
9.00	4.00	8.40	10.00	9.10	1.10	5.20
Clover and Timothy.				Clover-hay, Red.		
0.88	0.04	0.46	1.00	0.87	0.08	0.51
1.76	0.08	0.92	2.00	1.74	0.15	1.02
2.63	0.12	1.39	3.00	2.61	0.23	1.53
3.51	0.16	1.85	4.00	3.48	0.30	2.04
4.39	0.20	2.31	5.00	4.36	0.38	2.54
5.27	0.24	2.77	6.00	5.23	0.46	3.05
6.15	0.28	3.23	7.00	6.10	0.53	3.56
7.02	0.32	3.70	8.00	6.97	0.61	4.07
7.90	0.36	4.16	9.00	7.84	0.68	4.58
8.80	0.40	4.60	10.00	8.70	0.80	5.10
Clover-hay, Alsike.				Pea and Oat Hay.		
0.88	0.08	0.47	1.00	0.83	0.08	0.49
1.75	0.16	0.95	2.00	1.67	0.17	0.98
2.63	0.24	1.42	3.00	2.50	0.25	1.46
3.51	0.32	1.89	4.00	3.34	0.33	1.95
4.38	0.40	2.36	5.00	4.17	0.42	2.44
5.26	0.47	2.84	6.00	5.00	0.50	2.93
6.14	0.55	3.31	7.00	5.84	0.58	3.42
7.02	0.63	3.78	8.00	6.67	0.66	3.90
7.89	0.71	4.26	9.00	7.51	0.75	4.39
8.80	0.80	4.70	10.00	8.30	0.80	4.90
Timothy-hay, All Analyses.				Corn Silage, Well Matured.		
0.88	0.03	0.48	1.00	0.26	0.01	0.18
1.77	0.06	0.97	2.00	0.53	0.02	0.35
2.65	0.09	1.46	3.00	0.79	0.03	0.53
3.54	0.12	1.94	4.00	1.05	0.04	0.71
4.42	0.15	2.42	5.00	1.32	0.06	0.88
5.30	0.18	2.91	6.00	1.58	0.07	1.06
6.19	0.21	3.40	7.00	1.84	0.08	1.24
7.07	0.24	3.88	8.00	2.10	0.09	1.42
7.96	0.27	4.36	9.00	2.37	0.10	1.59
8.80	0.30	4.80	10.00	2.60	0.10	1.80

TABLE NO. 15—*Continued.*

Oat and Pea Silage.				Pea-cannery Refuse Silage.		
Dry Matter.	Digestible Crude Protein.	Total Digestible Nutrients.	Amount.	Dry Matter.	Digestible Crude Protein.	Total Digestible Nutrients.
Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
0.28	0.03	0.18	1.00	0.23	0.02	0.15
0.55	0.06	0.35	2.00	0.46	0.03	0.30
0.82	0.08	0.53	3.00	0.70	0.05	0.45
1.10	0.11	0.70	4.00	0.93	0.06	0.60
1.38	0.14	0.88	5.00	1.16	0.08	0.75
1.65	0.17	1.06	6.00	1.39	0.10	0.90
1.92	0.20	1.23	7.00	1.62	0.11	1.05
2.20	0.22	1.41	8.00	1.86	0.13	1.20
2.48	0.25	1.58	9.00	2.09	0.14	1.35
2.80	0.30	1.80	10.00	2.30	0.20	1.50
	Carrots.				Beets, Sugar.	
0.12	0.01	0.10	1.00	0.16	0.01	0.14
0.23	0.02	0.20	2.00	0.33	0.02	0.28
0.35	0.03	0.30	3.00	0.49	0.04	0.42
0.47	0.04	0.40	4.00	0.66	0.05	0.56
0.58	0.04	0.50	5.00	0.82	0.06	0.70
0.70	0.05	0.59	6.00	0.98	0.07	0.84
0.82	0.06	0.69	7.00	1.15	0.08	0.98
0.94	0.07	0.79	8.00	1.31	0.10	1.12
1.05	0.08	0.89	9.00	1.48	0.11	1.26
1.20	0.10	1.00	10.00	1.60	0.11	1.40
	Mangels.				Potatoes.	
0.09	0.01	0.07	1.00	0.21	0.01	0.17
0.19	0.02	0.15	2.00	0.42	0.02	0.34
0.28	0.02	0.22	3.00	0.64	0.03	0.51
0.38	0.03	0.30	4.00	0.85	0.04	0.68
0.47	0.04	0.37	5.00	1.06	0.06	0.86
0.56	0.05	0.44	6.00	1.27	0.07	1.03
0.66	0.06	0.52	7.00	1.48	0.08	1.20
0.75	0.06	0.59	8.00	1.70	0.09	1.37
0.85	0.07	0.67	9.00	1.91	0.10	1.54
0.90	0.10	0.70	10.00	2.10	0.10	1.70

Rutabagas.

Amount.	Dry Matter.	Digestible Crude Protein.	Total Digestible Nutrients.	Amount.	Dry Matter.	Digestible Crude Protein.	Total Digestible Nutrients.
Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
1.00	0.11	0.01	0.09	6.00	0.65	0.06	0.56
2.00	0.22	0.02	0.19	7.00	0.76	0.07	0.66
3.00	0.33	0.03	0.28	8.00	0.87	0.08	0.75
4.00	0.44	0.04	0.38	9.00	0.98	0.09	0.85
5.00	0.54	0.05	0.47	10.00	1.10	0.10	0.90

Table No. 16.

Simple Method of computing Cost of Feeding-stuffs.—To use the table, multiply the coefficients for a given feed by the market price per ton. The results will be the cost in cents a pound for the respective nutrients. An example: To determine the cost per pound of total digestible nutrients in corn at $40 per ton, multiply $40 by 0.058, and the result is 2.32 cents.

Kind of Feed.	Coefficients.	
	Total Digestible Nutrients.	Digestible Crude Protein.
Carbonaceous concentrates—		
Barley	0.063	0.555
Beet-pulp, dried	0.069	1.087
Corn, Dent	0.058	0.667
Molasses, beet	0.082	4.545
Oats	0.071	0.515
Oat feed, low-grade	0.109	1.000
Rye	0.062	0.505
Concentrates medium in protein—		
Bran, wheat	0.082	0.400
Cottonseed feed	0.086	0.352
Distiller's grains, dry, rye	0.075	0.367
Middlings, wheat, standard	0.072	0.373
Rye feed	0.067	0.409
Concentrates high in protein—		
Brewer's grains, dried	0.076	0.232
Cocoanut-meal, low in fat	0.063	0.266
Cottonseed-meal, choice	0.064	0.135
Cottonseed-meal, prime	0.066	0.149
Distiller's grains, dry, corn	0.056	0.233
Gluten feed, high-grade	0.062	0.231
Linseed-meal, O.P.	0.064	0.166
Soy-bean meal, fat extracted	0.060	0.131
Fish-meal	0.070	0.083
Dried roughage—		
Alfalfa-hay	0.096	0.472
Clover-hay, red	0.098	0.657
Clover-hay, alsike	0.106	0.633
Clover and timothy	0.108	1.250
Pea and oat hay	0.102	0.602
Soy-bean hay	0.093	0.427
Sudan hay	0.101	1.852
Timothy-hay	0.103	1.667
Timothy-hay, cut before bloom	0.091	1.064
Silage—		
Corn, well-matured	0.282	4.545
Pea-cannery refuse	0.290	3.125
Roots and tubers—		
Beets, common	0.490	5.555
Beets, sugar	0.357	4.166
Carrots	0.505	5.555
Mangels	0.675	6.250
Potatoes	0.292	4.545
Rutabagas	0.532	5.000

(From Special Circular, May, 1923, College of Agriculture, University of Wisconsin, Madison.)

FISH-MEAL IN THE DAIRY RATION.

Some Suggested Rations.

Percentage of Fish-meal to be used.

	Digestible Crude Protein.	Crude Protein.
	Per Cent.	Per Cent.
(1.) 300 lb. ground wheat	9.2	12.4
300 lb. ground barley	9.0	11.5
300 lb. ground oats	9.7	12.4
100 lb. fish-meal	58.5	65.0
Average	14.1	17.3
(2.) 600 lb. ground oats	9.7	12.4
300 lb. screenings	9.2	12.0
100 lb. fish-meal	58.5	65.0
Average	14.4	17.5
(3.) 900 lb. ground oats	9.7	12.4
100 lb. fish-meal	58.5	65.0
Average	14.5	17.6

Use more Fish-meal with Low-protein Roughages.—Use either of above rations with alfalfa-hay and feed 1 lb. grain mixture to 3 or 3½ lb. milk.

If good mixed hay is being fed, increase the amount of fish-meal by 50 per cent. (that is, use 150 lb.) and feed 1 lb. grain mixture to 3 or 3½ lb. milk.

If timothy-hay is being fed, increase the amount of fish-meal to 200 lb. and feed 1 lb. grain mixture to 3 or 3½ lb. milk.

Mineral supplements are not usually required when pilchard-meal is fed.

METHOD OF MODIFYING AN EXISTING DAIRY RATION TO INCLUDE FISH-MEAL.

Pilchard-meal replaces other Protein Concentrates.

Quantity in Use.	Ingredient.	Quantity to Use.
500	Wheat-bran	500
300	Pulverized oats	300
300	Linseed oil-cake meal	200 (100 out)
200	Soya-bean meal	000 (all out)
200	Cottonseed-meal	000 (all out)
300	Ground barley	550 (250 add)
300	Corn-meal	300
None	Pilchard-meal	250
300	Dried brewer's grains	300
600	Dried distiller's grains	600

Cost of Ration reduced by Substitution of Fish-meal.—Thus, by taking out 100 lb. linseed oil-cake meal, 200 lb. soy-bean meal, and 200 lb. cottonseed-meal, and substituting therefor 250 lb. pilchard-meal and 250 lb. ground barley, the total quantity is the same; the percentage of digestible protein is also about the same, but the price will have been reduced by about $3.50 per ton.

Easy to change over to Ration containing Fish-meal.—If such a change were made your cows would take quite readily to the "modified" ration if it were substituted for the regular ration at the rate of about 10 per cent. per day; that is, if you intended feeding a cow 10 lb. grain, just give her 9 lb. of the old ration and 1 lb. of the new on the first day, 8 and 2 lb. the next day, 7 and 3 lb. the third day, and so on, taking ten days to make the complete change.

FISH-MEAL COMPARED WITH COTTONSEED-MEAL.

Three Pounds Fish-meal fed daily.—The fish-meal used in this experiment was prepared under the direction of F. C. Weber, Bureau of Chemistry. It was made from the waste in the canning of sardines by pressing out most of the oil and then drying and grinding the residue. The fish-meal was fed to six cows for two periods of seventy days each in comparison with cottonseed-meal. The other concentrates used in the ration were equal parts of corn-meal and wheat-bran. Alfalfa-hay was fed to each cow at the rate of 6 lb. a day with as much corn silage as would be consumed without waste. Fish-meal and cottonseed-meal were each supplied at the rate of 3 lb. per cow daily until near the end of the experiment, when it became evident that the fish-meal was superior to the cottonseed-meal. The allowance of fish-meal was then reduced and that of cottonseed-meal increased for the purpose of controlling the live weight.

Table A gives the analyses of the feeds used in this experiment; Table B shows the production, feed, and gain in body-weight; and Table C the ration of feed consumed to butter-fat produced.

TABLE A.—COMPOSITION OF FISH-MEAL AND COTTONSEED-MEAL.

Feed.	Moisture.	Ash.	Crude Protein.	Albuminoid Protein.	Ether Extract.	Crude Fibre.	Nitrogen-free Extract.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Fish-meal	5.82	17.60	61.07	.....	15.51	.....	.....
Cottonseed-meal	7.12	6.30	38.65	37.56	7.89	9.97	30.07

TABLE B.—COMPARATIVE RESULTS OF FEEDING FISH-MEAL AND COTTONSEED-MEAL.

Group.	Quantity of Feed.					Yield.		Gain in Body-weight.
	Grain.	Fish-meal.	Cotton-seed Meal.	Alfalfa-hay.	Corn Silage.	Milk.	Butter-fat.	
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Fish-meal groups	2,017	930.9	.....	2,026	10,410	7,829.5	350.22	99.5
Cottonseed-meal groups	2,030	.....	1,168	2,019	10,019	7,754.1	354.53	75.5

TABLE C.—FEED CONSUMED FOR EACH POUND OF BUTTER-FAT PRODUCED IN FISH-MEAL EXPERIMENT.*

Group.	Grain.	Fish-meal.	Cottonseed-meal.	Alfalfa-hay.	Corn Silage.
	Lb.	Lb.	Lb.	Lb.	Lb.
Fish-meal groups	5.76	2.66	.....	5.78	29.7
Cottonseed-meal groups	5.73	.....	3.29	5.69	28.3

* This experiment indicates that 1 lb. of fish-meal is equal to about 1.24 lb. of cottonseed-meal.

Cows fed Fish-meal gain in Weight.—It will be noted that the fish-meal groups produced slightly more milk but a trifle less butter-fat, while the grain and alfalfa-hay were practically the same for each group. The fish-meal groups consumed almost 400 lb. more silage, but to offset this they gained 24 lb. more in body-weight than the other group. Perhaps it may be assumed that one will about balance the other, and if so we have a direct comparison between the fish-meal and cottonseed-meal. Apparently, for dairy cows, the fish-meal is worth pound for pound 20 or 25 per cent. more than cottonseed-meal.

Fish-meal did not impair Milk Flavour.—Fish-meal is not so palatable as cotton-seed-meal, though no difficulty was experienced in getting the cows to eat all that was offered them. No bad effects on the physical condition of the cows were observed. The flavour of the milk apparently was not impaired in any way either by exposing milk to the odour of fish-meal or by feeding the cows 4 lb. of the fish-meal one hour before milking. While it cannot be positively stated that fish-meal has no bad effect whatever on the flavour and odour of milk, such effect, if any, is so slight as to be unnoticed by the ordinary consumer.

High Oil Content of Fish-meal not Detrimental.—In the foregoing project, planned to establish the merit of fish-meal in comparison with cottonseed-meal, it is worth while noting that the fish-meal used contained 15.51 per cent. of fat (ether extract) and that no objections to such a high oil content were noticed.

Fish-meal required to maintain Body-weight and Milk Production.—As in all other trials with fish-meal in the dairy ration, it is seen in this one that the animals made a notable gain in weight. It is not at all likely, however, that this gain in weight was fat, but more likely it was lean meat (protein). Always, whenever the proper quality and quantity of protein is supplied to an animal in milk, continued high production is possible without the usual loss of body-weight consequent upon the use of protein concentrates deficient in one or more of the essential amino-acids. Fish-meal protein is "complete" in that it contains all of the amino-acids found in milk; therefore its use in the dairy ration is necessary if high milk production plus maintenance of body-weight is to be expected.

THE FEEDING OF FISH-MEAL TO CALVES.

Feed the Calf carefully.—"Probably more than any other animal, the calf, deprived prematurely of its natural food, requires most careful attention as to feeding. It is essential that any artificial substitutes used for calf-rearing should be as nearly as possible comparable in constitution to cow's milk, and for this reason: the use of some protein of animal derivation is demanded. It is also necessary to ensure that the calf-meal contains adequate supplies of the mineral matter which is so important a constituent of milk. The calf-meal should also be easily digested. *Fish-meal* represents, therefore, an excellent ingredient for a meal for this purpose, and its use is attended with success.

Substitutes for Whole Milk.—"Methods of calf-rearing vary considerably, but, in general, the calves receive whole milk for the first three weeks of their lives, from which time substitution in some form or other is gradually made. In dairying districts whey or separated milk may be used, whilst in others as the milk is reduced the supply of dry mixture is introduced, water being also given.

Fish-meal and Oatmeal Porridge for Calves.—"In the experiments of the West of Scotland Agricultural College, a mixture consisting of ⅔ oatmeal and ⅓ fish-meal, made into porridge with boiling water and then fed along with whey, gave good results. 'The calves took quite kindly to this ration from the very beginning, no difficulty being experienced in getting them to take it.' In the same trials a mixture of 2 parts thirds (shorts) and 1 part fish-meal, also fed as porridge with whey, gave quite satisfactory results, and again no difficulty was experienced in getting the calves to take readily to the ration.

Fish-meal used in Dry Grain Mixtures.—"With regard to dry mixtures for calf-feeding, the following are recommended by Mr. James Mackintosh, of the National Institute for Research in Dairying:—

		Parts.
(1.)	Linseed-cake	4
	Maize (corn) meal	3
	Fish-meal	1
(2.)	Linseed-cake	4
	Bean-meal	4
	Crushed oats	4
	Maize (corn) meal	3
	Fish-meal	1

	Parts.
(3.) Linseed-cake	3
Crushed oats	3
Barley-meal or flaked maize	3
Fish-meal	1

Amounts of Fish-meal and Grain to feed.—"These meals are gradually introduced after the third week as the milk is reduced in quantity, commencing with a handful daily and increasing until the calf is getting about 2½ lb. daily at about six weeks old and rather more at three months."—*Corrie.*

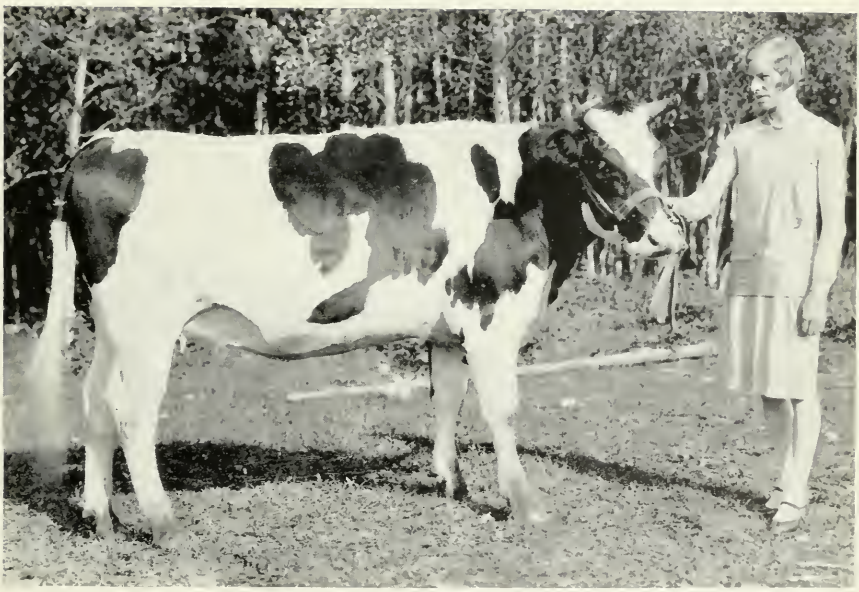
Fish-meal Minerals Ideal Substitute for Milk Minerals.—"Meals and cakes vary in composition according to their source. In general they are poor in lime and rich in phosphorus. Fish-meal made from the bones and soft tissues of fish is very rich in mineral matter, which, in composition, approximates somewhat closely that required for growth or milk formation. The same is true, of course, of the dry matter of milk residues."—*Orr.*

TABLE NO. 17.—NORMAL WEIGHT OF DAIRY-BREED FEMALES DURING THE GROWING PERIOD TO TIME OF FIRST CALVING.

(From North Dakota Agricultural College, Circular 51. Copied from Missouri Research Bulletin No. 36.)

Compare the Weights of your Calves by this Table.

Age in Months.	NORMAL WEIGHTS IN POUNDS.			
	Holsteins.	Jerseys.	Ayrshires.	Shorthorns.
Birth	90	55	69	73
1	121	76	90	118
2	157	105	128	133
3	200	140	170	174
4	249	174	218	225
5	302	222	254	268
6	349	260	286	316
7	389	302	304	348
8	425	340	336	419
9	466	376	361	466
10	501	407	406	538
11	529	432	427	576
12	558	456	456	547
13	574	480	485	564
14	596	503	533	579
15	612	520	547	617
16	643	533	560	627
17	660	553	579	642
18	686	572	604	668
19	715	598	627	695
20	746	621	651	728
21	774	649	679	745
22	796	668	707	741
23	824	689	733	821
24	841	716	759	845
25	869	737	798	845
26	893	758	807	877
27	925	770	859	885
28	966	784	.....	922
29	994	804	.....	928
30	1,021	.....	.....	998



PURE-BRED HOLSTEIN HEIFER.

Name, Canary Pietje Mechthilde (203803) ; born, September 23rd, 1928 ; sire, Strathmore Sylvius Pietje (70839) ; dam, Strathmore Texaline Mechthilde (79078) ; owner, William Weaver, Natal, B.C.

Feed fish-meal to your calves. Mr. Weaver recommends it.

Weight and Gains made by Hand-fed Calves at the Montana Experimental Station.

	At Birth.		At 76 Days.		At 168 Days.		At 259 Days.	
	No.	Av. Wt.	No.	Av. Wt.	No.	Av. Wt.	No.	Av. Wt.
Holsteins—								
Males	44	100.7	37	219.4	28	419.9	17	623.5
Females	47	95.2	38	206.7	37	362.1	34	532.4
Jerseys—								
Males	15	60.5	10	139.1	9	302.8	6	466.7
Females	28	54.2	27	126.6	27	256.6	26	377.7

Different Strains may grow at Different Rates.—Table No. 17, page 36, gives the normal weight of dairy-breed females during the growing period to time of first calving. It is altogether likely that the figures in this table should be considered with reservations, for it is possible that certain "strains" or "families" of dairy cattle may be either above or below these figures for any given age and still be "normal" so far as that particular strain is concerned.

Normal and Optimum Gains considered.—It is also a debatable point whether "normal" weights, such as those given in Table No. 17, are anything like optimum weights; and as we know of no tables giving the optimum weights of dairy-breed females, we have no real basis for comparing the weights of certain calves which are far in excess of the normal weights given. We are, therefore, presenting the following data for the interest it is sure to excite amongst dairymen who desire to exceed the normal rate of growth. Whether or not there is any advantage in increasing the normal rate of growth we are not prepared to argue at the moment, but it would appear that, within reason, the normal rate of gain might be exceeded without any harm.

Pure-bred Holstein Calves weighed for Comparison.

Calf No.	799.	800.	801.	802.
Date born	11/22/29	11/22/29	11/23/29	11/28/29
Weight, Jan. 7/30	175	155	.....	.....
Weight, Jan. 29/30	215	195	204	188
Weight, Feb. 12/30	251	222	238	220
Weight, Feb. 26/30	276	246	276	258
Weight, Mar. 12/30	320	284	307	298
Weight, Mar. 26/30	365	330	355	340
Weight, Apr. 23/30	415	365	415	380
Weight, May 22/30	500	440	475	460

Normal Weights easily exceeded.—From the foregoing figures it will be seen that Calf No. 799 at six months of age was 151 lb. heavier than "normal" in Table No. 17; at three months of age, however, the same calf was only 55 lb. above normal. On January 7th Calves 799 and 800 were given in addition to their regular ration about 2 oz. daily of a mixture of fish-meal and dried kelp, the amount being gradually increased until at about five months they were each getting ½ lb. daily of the supplement. About 15 lb. of fish-meal and kelp have, therefore, brought about well over 100 lb. of gain.

The regular ration of Calves 801 and 802 was supplemented on January 29th, 1930, according to the following plan:—

Simple Method of supplementing Calf Ration.—Pilchard-meal was added to the ration at the rate of 1 oz. daily for 1 week, then 2 oz. daily for 2 weeks, then 4 oz. daily for 4 weeks, then 8 oz. daily for 8 weeks, and so on.

Fish-meal Supplement Accounts for Additional Gains.—When these calves were a little over two months old they were 47 and 31 lb. each above normal weight; at about six months of age they were 126 and 111 lb. each above normal. These calves (799 to 802) were considered by judges with the highest qualifications to be in the "pink" of condition each time they were weighed.

The amounts of gain from the fifth to the sixth month is, respectively, 85, 75, 60, and 90 lb., which is from 2 to 3 lb. gain each day as against a maximum of 1½ lb. daily as given in Table No. 17.

From Two to Three Pounds daily gained by Calves on Fish-meal.—Very small amounts of fish-meal added to a ration for a young calf apparently accounts for nearly 3 lb. of gain for each pound fed; that is economical growth, and easily obtained by any one wishing to have his calves grow at a rate in excess of "normal."

WHAT USERS OF FISH-MEAL SAY ABOUT IT.

Mr. Alfred Johnson, Supervisor, North Okanagan Cow-testing Association, writes to us in part as follows:—

"The members of our Cow-testing Association have been using fish-meal. Mr. Ivan H. Wright, a very successful dairyman, used it all last winter and spring instead of oil-cake meal. His cows did well on this feed. He used half as much as he would have with oil-cake meal. Fish-meal was $4 and oil-cake meal $3.50 per 100 lb., so there was a considerable saving. Mr. Alan Allardice, another member, uses it right along in his mixture for pig-feed. I do not know the proportion he uses, but his pigs certainly fatten up quicker than most pigs in this district. They get a fair amount of milk, barley-chop, and fish-meal, but no green feed at all. Mr. F. Ibbotson also uses fish-meal as a high protein ingredient of the grain mixture for cows."

T. H. Jagger, V.S., B.V.Sc., of Vancouver, writes the editor in part as follows:—

"Fish-meal for dairy cows. I am very interested in this subject, and while I have no direct evidence to offer, yet I feel that it will prove to be a valuable supplement food for cattle. A lot of our dairy cows give evidence of a lack of some element, or elements, in their present food-supply. It is just possible that the feeding of fish-meal may correct some of this deficiency."

THE INFLUENCE OF FEEDING ON HEALTH.

Cumulative Effect of Deficiencies in Rations.—"One would expect that the evil effects of improper feeding would be specially marked in heavy-milking cows. They are often stall-fed, on a monotonous diet, for months on end, so that the effects of deficiency or excess of any constituent of the ration would tend to be cumulative, and the drain on the body, caused by the secretion of milk, would tend to exhaust any reserves which, in the case of a non-lactating animal, might tide it over until the defect was rectified by a change in the ration.

Tuberculosis, Abortion, and Sterility in Dairy Cows.—"There are no statistics available to show to what extent disease is prevalent among dairy cows. It is known, however, that preventable disease causes a heavy loss. A majority of the cows in this country are victims of tuberculosis; abortion has become a serious menace to the whole industry, and sterility is one of the bugbears of the breeder of heavy milkers. Unfortunately, we have no figures to show whether or not there has been an increase in the incidence of these diseases associated with the increase in milk yield and the increase in the use of commercial by-products, which, as we have seen, form an imperfectly balanced ration for milk production. But what evidence is available seems to indicate that there is a casual relationship between these diseases and the feeding of a ration that is deficient in certain essential substances required for milk production. Forbes (19), of the Ohio Experimental Station, U.S.A., attempted to collect evidence on this subject. Such information as he was able to obtain indicated that heavy milkers, with long lactation periods, were specially liable to sterility.

Effect of Feed on Resistance to Disease.—" In a previous article in the 'Transactions' (2), the writer has referred to the difficulty in obtaining information with regard to the correlation between tuberculosis and the depletion of the cow's tissues caused by heavy milking on an imperfect diet. The data that do exist, however, suggest that a high milk yield and an imperfect diet predispose to infection. Recently some observations have been made at the Beltsville Experimental Station, U.S.A., by Meigs (20) and his associates, who report as follows: 'There is one other aspect of the case which must be discussed. Quite apart from the question of the feed cost per pound of milk when a cow's yield is reduced by feeding a ration deficient in one or more necessary constituents, is the question of the effect of this process on her capacity to resist disease. The Beltsville herd has suffered severely in the last three years from contagious abortion. The relation between the incidence of this disease and the manner in which the cows have been fed is being carefully studied at present, and the results of this study will be reported later. The results already obtained, however, are sufficient to justify a strong suspicion that abortion has occurred more frequently among the animals that were less adequately fed.'

Proper Feeding may reduce Number of T.B. Reactors.—" This view, that imperfect feeding is a very important factor contributing to the prevalence of these diseases, is now shared by many of the practical experts in this country with whom the writer has been in communication. This aspect of the question ought to be considered in all discussions with regard to the prevention or cure of these diseases. If, for example, a high milk yield associated with a faulty ration predisposes to tuberculosis, the policy of wholesale slaughter of tuberculous cows is likely to be more remarkable for its expense than for its success. Slaughter serves two purposes—to remove a source of infection, and, it is claimed, to prevent breeding from a susceptible stock.

Influence of Nutrition on Susceptibility to Disease.—" With regard to the former point, infective material is probably already practically universally present, and even very extensive slaughter will not get rid of it. As to the second argument, while there is no doubt that certain stocks are more susceptible than others, the great influence of nutrition on susceptibility must be remembered. If all the animals were equally well fed and housed, then the incidence of the disease might be taken to correspond to degree of inherited susceptibility, and the elimination of reactors would in time lead to the breeding of a race with high powers of resistance.

Difference between Inherited and Nutritional Susceptibility.—" But at present it is difficult to differentiate between inherited and nutritional susceptibility. Correct feeding to maintain the natural resistance of the animal to tuberculosis would seem to be the first line of defence against the disease. Animals that do succumb, though properly fed, are likely to have an inherited susceptibility, and therefore to belong to a strain that should be eliminated by slaughter."—*Dr. J. B. Orr, Rowett Institute, Aberdeen.*

Fish-meal in the Dairy Ration may prevent Deficiency Diseases.—" The writer has for some time been endeavouring to get information with regard to the correlation between the incidence of tuberculosis and (a) milk yield, and the mineral content of the diet. The information with regard to the influence of the diet, though scanty and lacking in precision, seems to indicate that cows fed on ill-balanced rations, consisting mainly of distillery grains, meals, and cakes rich in proteins, which stimulate the flow of milk, and poor in certain minerals required for the milk, succumb earlier to the disease than those with a good mixed ration containing feeding-stuffs rich in well-balanced minerals such as silage, clover-hay, and fish-meal."—*W. T. Conn, Technologist, U.S. Bureau of Fisheries.*

SOIL DEFICIENCIES IN THE FRASER VALLEY AND THEIR EFFECT ON THE HEALTH OF ANIMALS.

Fraser Valley Soil Deficiencies.—It has long been known that Fraser Valley soils are deficient in a number of constituents which are considered essential, and that these

deficiencies have had an injurious effect on animals which are pastured thereon, or which are fed largely on the products of these deficient soils. With the idea of getting some authoritative data in this regard, we have consulted R. G. Sutton, B.S.A., District Agriculturist, New Westminster, who has this to say:—

Exceptions.—"In regard to mineral deficiencies in soils of the valley, I think one can safely make a blanket assertain that such deficiency is very general all through the valley; the only exceptions to this rule being a few local areas of soil which, fortunately, have an extra large reserve of mineral matter.

Bench Soils Specially Low in Minerals.—"Soils of the 'bench' type have been subject to tillage and rainfall for a number of years and have, accordingly, lost much of their original mineral content through seepage and cropping. Soils of the lowlands are, to a large extent, composed of vegetable matter and thus have little natural mineral content. Hence the general nature of the deficiency.

Dairymen must add Minerals to Rations.—"The proofs of this are found in the fact that practically every dairyman finds it necessary to feed a certain amount of mineral in his ration. Also in the fact that goitre appears commonly in calves in some localities and hairless or deformed pigs sometimes appear.

Live Stock prefer Mineralized Areas.—"Further proof may be seen where a man has treated one part of a pasture-field with mineral fertilizer, bone-meal, or even lime. Such cases have come under observation and it has been noticed that invariably the stock will neglect the untreated part of the field and devote their time to the treated part. Sometimes to the extent of eating the grass on the treated part of the field down till they are pulling the very roots, while the untreated part of the field grows lush and green.

Pasture Deficiencies and Low Milk Yield.—"Evidence of apparent lack of minerals in rations has been seen in a number of cases in the valley in failure to breed, poor condition after winter-feeding, otherwise unaccountable dropping-off in milk-secretion, and undue brittleness of bones.

Young Pigs also Suffer.—"Several cases have come under observation of the writer this year where there was pronounced lack of thrift in young pigs, even those on pasture. Accompanying this was weakness of joints. In each case distinct improvement resulted from feeding some form of mineral or even wood-ashes."

Soils need Calcium and Phosphorus mostly.—"The most common forms of deficiency diseases (caused by soil and pasture deficiencies) are believed to be due to deficiency of phosphorus or calcium. It may also be true that some of the diseases are due to a deficiency of both these minerals. They are characterized by general unthriftiness, emaciation, stiffness of gait, and inco-ordinated movement. Post-mortem examination usually shows softness or fragility of the bones. A very common symptom is 'depraved' appetite, which leads to the chewing or eating of substances which have no attraction for a healthy animal.

Malnutrition caused by Shortage, Common Salt, Manganese, Copper, Iron, Boron, etc.—"The effects of deficiency of phosphorus, calcium, iodine, and iron have been studied more extensively than the effects of deficiency of other minerals. It is known, however, that lack of common salt, which provides sodium and chlorine, causes malnutrition, especially in milk cows. But the question of possible deficiency of manganese, zinc, copper, boron, and other elements which are known to have an influence on the physiological processes of the body have not been studied. We have very little knowledge as to the amounts of these present in different pastures or as to the amounts which animals require. It may well be that minute traces of some of these elements which are present as impurities in salt-licks and mineral mixtures sometimes fed to animals may be responsible to some extent for the beneficial effects at present credited to other substances."—*J. B. Orr.*

Fish-meal is Cheap Source of Minerals.—We have seen numerous instances in the Fraser Valley and in other parts of the Province of beneficial results from the feeding of fish-meal which could not be accounted for except by considering the mineral content alone. We have a very good idea of what to expect when fish-meal is fed for its protein content, but we so often find other beneficial effects that cannot be attributed to the feeding of even the best quality of protein that we are more or less bound to attribute these beneficial effects to some other compounds in the fish-meal. For instance, we have seen as small a percentage as 10 of fish-meal in a ration totally eliminate " hairless " pigs in an area where such litters were all too common. The iodine content of pilchard-meal is therefore evidently quite sufficient to eliminate this condition when the fish-meal is fed at the rate of 10 per cent. of the total ration. We have also had reports from reliable dairymen in the Fraser Valley that since feeding pilchard-meal they have not had a case of retained after-birth, whereas, before, such cases were common. No cases of goitre have been reported from farms where fish-meal is regularly fed, and while it is not suggested that the iodine content of pilchard-meal is sufficient to bring about a cure of an existing case of goitre, it is apparent that the regular feeding of fish-meal does prevent the appearance of this disease.

Fish-meal corrects Mineral Deficiencies.—As fish-meal contains all of the minerals ordinarily found in the body, one may rightfully expect to safeguard the health of his animals from most of the so-called " deficiency " diseases by feeding fish-meal in adequate quantities. It may be granted that very little is known of the effect of deficiency of iron, copper, etc., in the ration or in the animal body, but as " an ounce of prevention is worth a pound of cure " it would therefore be advisable to feed a product, such as fish-meal, which is known to contain all of the required minerals in a form readily assimilable by the animal body.

Effects of Fish-meal on Sterility.—The cost to dairymen in British Columbia of sterility, or failure to breed, has never been estimated, but it is certain that the amount would be tremendous, and while the feeding of fish-meal has not eliminated this condition altogether, we have many reports from creditable sources that within a few months after starting to feed fish-meal the average number of services has been reduced nearly 50 per cent. If for no other reason than this, the feeding of fish-meal should become a regular habit.

Abortion reduced by Fish-meal.—Nothing definite regarding the effect of fish-meal in the ration on abortion is known. We do know, however, of cases where abortion has been lessened since the incidence of fish-meal in the ration. Possibly the number of cases of abortion would have been lessened without having added fish-meal to the ration, but that is also unknown, and very doubtful. As the cost of one case of abortion in a good animal far outweighs the cost of a year's supply of fish-meal for any animal, it should behove any farmer to include an adequate quantity of fish-meal in all his rations. Abortion is one of those diseases which seems to run its course and then disappear for a time, but that is no reason why we should not take all of the known precautions against its spread. One of these precautions undoubtedly is the feeding of fish-meal.

Fish-meal not a Cure-all.—It is not intended that one should gather from the foregoing that fish-meal of any kind is a panacea for all the evils animal flesh is heir to, but in diseases known definitely to be due to deficiencies of one sort or another in the ration, fish-meal does suggest itself as being that one thing which can be expected to reduce or eliminate many of these "deficiency " diseases, especially those due to mineral deficiencies.

Lime and Salt not all Minerals required.—As Sutton and Orr have pointed out, various ailments results from inadequate supplies of some of the better-known minerals and that beneficial results are obtained by the feeding of such simple compounds as lime and common salt. Minerals such as these may be added to regular rations, but their indiscriminate use is to be avoided as injurious results have frequently been brought about by such practices. It would be better, and very likely less costly, to provide an animal with all of the minerals known to exist in its body rather than just the few needed, apparently, more than others. This is a simple matter—feed fish-meal.

Dairy Cows Most Susceptible to Sterility.—In connection with sterility, abortion, etc., Corrie points out that "Forbes, of the Ohio Station, found that sterility or failure to breed is more common amongst dairy cows than beef cows, which he attributed to the drain of minerals from the body, resulting in a condition of low vitality in which reproduction is impossible.

Abortion caused by Deficiency of Lime and Phosphorus.—"Abortion and the production of premature, ill-nourished offspring may well result from deficiency of lime and phosphorus, factors which are so essential to the building-up of the unborn. Hart, Steenbock, and Morrison (Bulletin 350, Wisconsin Station) instance a cow which received a ration of ground oats and oat-straw during her entire gestation period. A premature and weak calf was born. The investigators wrote: 'This result invariably follows from the continued use of roughage poor in mineral content, particularly lime.'

Deficient Rations soon deplete Store of Minerals.—"The continued feeding of rations deficient in lime and phosphorus necessitates depletion of the stores of these constituents in the animal's bone, with consequent reduction of constitutional strength, of milk yield, and of resistance to disease. Tuberculosis, Johne's disease, abortion, and other common troubles of dairy stock indicate a lowered resistance to disease attack attributable, in all probability, to deficiency of mineral matter. Tuberculosis is more common in animals of the milk than of the beef type, and in heavy milkers than in cows of average yield."

Limited Knowledge of Deficiencies.—"Even with our present limited knowledge it is possible to state some facts that are worth keeping in view in arranging rations:—

"1. Failure to grow at the maximum rate and also certain diseases may be due to deficiency of certain minerals in the food or a lack of the proper proportion of the minerals to each other.

"2. Lime, one of the minerals which is required in large amounts, is markedly deficient in grains and grain-offals.

"3. Green foods, especially leguminous plants like clover, are rich in lime. These and foods derived from them, such as silage and clover-hay, correct the mineral deficiency of grains and meals.

"4. The value of milk and milk residues, such as whey solids, which contain most of the mineral matter of the milk, is largely due to the fact that they contain all the essential minerals in the amounts and proportions required by the growing animal, and the well-recognized value of clover pastures, leguminous silage, *fish-meal,* and other foodstuffs rich in lime depends largely upon the fact that the mineral matter contained in them corrects the deficiencies of grain, grain-offal, and many other concentrates."—*Orr and Husband.*

IODINE FOR CATTLE.

"A consideration of the question as applied to dairy cattle has been left to the last, largely for the reason that less definite information would seem to be available concerning the protective influence of iodine toward certain ailments affecting this class of stock.

Prevent "Big-neck" in Calves with Iodine.—"This much would appear as well authenticated. Goitre or 'big-neck' in calves, frequently a serious condition, may be controlled by the administration of iodine to pregnant cows. With cattle generally, the most practical means of administration is through the medium of salt mixtures. Commercial iodized salt, used regularly, will likely prove satisfactory. Where it is thought necessary to use it during the pregnant period only, and particularly where the treatment is directed toward the control of persistent appearance of goitre in calves, a home mixture of from 2 to 4 oz. per 100 lb. of salt might prove more reliable. In that some cows consume comparatively small quantities of salt, the method of treatment given under the heading 'Swine,' in which it will be noted treatment for cows is mentioned, could be used. This method is more certain in application than where iodized salt is used, but less convenient and practical of administration.

Iodine Most Effective during Pregnancy.—" Throughout the foregoing it will be seen that iodine would seem to exert a powerful influence for good *during the period of pregnancy*. What protective effect might the administration of iodine have in the case of genital infections of cattle causing premature birth, retained membranes, sterility, and other troubles? Much would be given by the writer at this juncture to claim definitely on well-proven grounds that such administration was effective. Such claims have been made, but are not well authenticated as yet.

Iodine Treatment for Genital Diseases.—" This much would seem quite clear to any one who has given much study to modern research in the matter of genital disease; no man need expect a rapid return to normal conditions in a herd affected with some form of genital infection (commonly known under the general name of infectious or contagious abortion) simply by the regular administration of iodine to his cows. What might result through the use of this treatment in the way of disease resistance, when applied over a period of time, yet remains to be seen. However, there is one aspect of the question as yet not definitely mentioned, although having a direct and obvious bearing on each consideration taken up in these paragraphs. To illustrate, the following quotation is taken from a recently issued pamphlet as representing a summary of work done in connection with iodine ('Iodine for Live Stock,' by Frank Ewart Corrie, B.Sc.): 'The influence of iodine in establishing and maintaining the *natural powers of resistance has been referred to by many research workers and demonstrated repeatedly in careful laboratory experiments.*' Unquestionably, in the experience of the Central Experimental Farm, lambs, pigs, foals, and calves from iodine-treated mothers would seem to have increased strength and vitality, and therefore likely increased resistance to disease. Such would seem to explain the effectiveness of the treatment in the case of foals, with reference to an infection in nearly all cases acquired at or immediately following birth. Strong foals are enabled to resist infection.

" In the case of genital infection, however, as producing, say, abortion, the infection is acquired prenatally or at varying periods before birth. To what extent resistance to disease may be effected in the case of the fœtus is not clear at present.

Effect of Iodine-feeding is Indirect.—"The indirect effect is possibly most important of all. Research studies have shown that a deficiency of iodine intake has a *direct and certain effect on the assimilation and control of such essential minerals as calcium and phosphorus in the animal body, no matter how abundantly they may be fed.* Such being the case, it would seem well to ensure the proper assimilation of the fundamental mineral requirements of the body by the use of, say, an iodized salt. Particularly in this the case when one considers the quantity of mineral matter in the milk produced by a 20,000-lb. cow.

Make Iodized Salt at Home.—" Finally, from indications with dairy cattle and from the knowledge of the general effect of potassium iodide, it would seem like wise practice to utilize an iodized salt during the milking period, and particularly during the period of pregnancy. The commercial variety might be used regularly, or, in cases of specific trouble from goitre in calves, weak calves, or genital infections, a home-mixed salt as described for sheep might be indicated."—*From "The Significance of Iodine in the Feeding of Live Stock," by George B. Rothwell, B.S.A., Dominion Animal Husbandman.*

Fish-meal proven Good Source of Iodine.—" During the past year, at the Central Experimental Farm, fish-meal, in addition to iodized salt, has been receiving some attention as a source of iodine for dairy cattle. It contains about 10 grains of iodine per hundred-weight. When it was fed to the cattle at a rate of about one-tenth of the concentrates a marked increase in the iodine content of the milk was noticed, thus showing that the iodine of the meal had been absorbed into the system of the animals. Fish-meal has long been recognized as a source of calcium and phosphorus. It must now also be recognized as a source of iodine."—*Cyril J. Watson, Chemistry Division, Central Experimental Farm, Ottawa, in Seasonable Hints, Autumn, 1929.*

PART II.—FISH-MEAL IN THE SWINE RATION.

Feeding Fish-meal to B.C. Swine.—Fish-meal has been fed to swine for a longer time than to dairy cows—that is, in British Columbia at least—and more data of a really authentic sort are available. Thus, at the Experimental Farm, Agassiz, experiments have been carried out there each year with the object of determining the relative value of fish-meal and skim-milk, as well as a comparison of fish-meal and beef-scrap or tankage. Detailed information on these experiments will be found in this section with comments of the Superintendent, Mr. W. H. Hicks, and with further comment by the editor of this bulletin.

Consumption of Fish-meal by Swine is Large.—No accurate data on the feeding of fish-meal to swine in other parts of the Province are available for publication at this time, but, judging altogether from the amount of fish-meal which has gone into consumption by hog-feeders in the past year or two, it would be safe to say that results equal to, or better than, those obtained at Agassiz are being secured by private feeders.

THE VALUE OF FISH-MEAL AS A FEEDING-STUFF FOR PIGS.

Assimilation of Fish-meal by Growing Animals.

Digestibility of Fish-meal for Swine.—"The value of a feeding-stuff depends not upon the percentage of the nutritive constituents present, but upon the extent to which these can be digested and absorbed by the alimentary canal and utilized by the living tissues. The two chief constituents of fish-meal are the protein and the mineral matter, which together form about three-fourths of it. Experiments were made to test the value of these to the growing animal.

Digestibility of Protein.

Over 90 per Cent. Fish-meal Protein digested.—"This was tested with a young pig which during the experiment was given a constant ration. For five days in the middle of the period, 100 grams of fish-meal was added to the ration. The amount of undigested protein (nit. x 6.25) in the fæces was determined daily. The following table shows the results:—

Digestibility of Fish-meal Protein.

	Intake in Food.	Amount in Fæces.	Amount digested and absorbed.
	Grams.	Grams.	Grams.
Ration only	136	29	107
Ration plus 100 grams fish	197*	33	164
Ration only	136	28	108

* 136 plus 61 of fish-meal.

"The addition of 61 grams of fish-meal protein caused a rise of 4 grams of protein in the fæces, so that 57 grams must have been digested and absorbed. The pig can, therefore, utilize over 90 per cent. of the protein.

Utilization of Lime and Phosphorus.

Fish-meal Minerals readily digested.—"These are the chief constituents of bones and are the two minerals required in greatest amounts by the growing body. In some forms, however, only a small percentage of these can be digested and absorbed. It has also been found that in any ration the amount of either that can be utilized depends upon the amount of the other that is present. In fish-meal the ratio of calcium to phosphorus is about the same as is required for growth, and it might be expected that the percentage of utilization would be high. That this is so is shown by the results of the experiment recorded below.

Scientific Methods used.—"A growing pig was given a constant ration and for a five-day period in the middle of the experiment there was added to the food 100 grams of

fish-meal per day. The amounts of calcium and of phosphorus excreted in both urine and fæces were determined.

Utilization of Lime and Phosphorus.

	Lime as (CaO).		Phosphorus as (P_2O_5).	
	Intake.	Retained.	Intake.	Retained.
	Grams.	Grams.	Grams.	Grams.
Ration only	0.65	0.13	6.9	3.7
Ration plus 100 grams fish-meal	12.20	4.70	17.4	8.4
Ration only	0.65	*Nil*	6.9	3.4

Over One-third Fish-meal Minerals utilized.—"Of the amounts of these two essential minerals given in the fish-meal, more than a third was utilized by the animal and the amounts utilized were just about what the animal would be expected to require."—*Orr, Crichton, and Green, Rowett Institute.*

Grain and Grain-offal lack Mineral Balance.—"The grains and grain-offal are markedly deficient in lime and have a relative excess of phosphorus. A pig four months old, if fed on a mixture of grains and grain-offal in Table No. 9, would require to eat 20 lb. per day to get its daily requirement of ⅓ oz. of lime (CaO), and in that amount it would have nearly 4 oz. of phosphorus (P_2O_5). *It is impossible with a ration consisting only of grain to get the mineral matter balanced to suit the animal."—Orr and Husband.*

MINERAL REQUIREMENTS OF PIGS.

Pigs need Minerals in Addition to Grain.—"Potatoes and cereal products, such as corn, bran, and oats, which are all commonly fed to pigs, are deficient in lime. When fed on these, without the addition of lime-rich foods, pigs are liable to suffer from soft bones and general malnutrition. This condition, which is of the same nature as rickets, which occurs in children, was recognized and the cause determined nearly fifty years ago by investigators in Germany. In the corn-growing areas of the United States great loss has been suffered from feeding pigs on corn without the addition of some other food to make good the mineral deficiency.

Rickets in Pigs.—"In Scotland there is a well-known disease in pigs, in which the young animals about three or four months old develop a rough staring coat, a stilted gait, loss of appetite, and sometimes loss of power of the hind legs. In bad cases fracture of the ribs and of the legs occur. The animals that grow fastest are most liable to the disease. Recent research at the Rowett Institute has shown that this condition is closely allied to, if not identical with, rickets. It is due to the want of balance in the mineral matter of the food, and can be prevented by the addition to the food of a mixture of inorganic salts, which makes the mineral composition of the whole ration somewhat similar to that of sow's milk. Green food, milk, and *fish-meal,* all supply the minerals usually lacking, and so help to prevent the disease. If the animals are allowed freedom, they usually find in pasture or in the soil the minerals lacking in their diet.

"It will be understood, of course, that every pig 'off its legs' is not necessarily suffering from lack of minerals. The pig is, unfortunately, subject to many diseases that put it 'off its legs.'

Phosphorus Deficiency produces Paralysis.—"Pigs do not commonly suffer from lack of phosphorus, as in most cases their food consists partly of cereal products, which are rich in this constituent. Experiments have been conducted, however, which show that, when phosphorus is lacking, stoppage of growth and paralysis of the hind legs soon occur. The condition can be cured in a few days by the addition of inorganic phosphorus to the food.

Anaemia in Pigs and Iron Deficiency.—"The rapidly growing pig requires considerable quantities of iron. In addition to a reserve store which it possesses at birth, it

receives a more generous supply in the milk than most animals. The percentage of iron in the milk may be modified by the food of the nursing mother. It is probable also that the store of iron at birth may be affected by the feeding of the mother during pregnancy. As sows are often fed on food with very little iron, there is the probability of sucking-pigs suffering from lack of this essential mineral.

Provide Pigs with Iron.—"This has been investigated at the Rowett Institute. McGowan and Crichton fed breeding sows on distillery draff, corn, and small quantities of fish-meal made from the bones and adherent flesh of whitefish. The ration supplied sufficient lime and phosphorus, and probably also all of the other minerals except iron. The litters were born apparently healthy, but after the third or fourth week malnutrition was evident. The animals were breathless on exertion, and there were a number of sudden deaths. Post-mortem examination showed that the hearts were enormously enlarged. The blood was thin and watery, and the hæmoglobin—the iron containing part of the blood—was in some cases only 15 per cent. of the normal. Other sows were fed the same ration with the addition of iron oxide. The litters from these were perfectly healthy.

Cottonseed Poisoning of Pigs.—"Further investigations are being carried out by these workers. Even from these preliminary experiments, however, it looks as if shortage of iron might be the unrecognized cause of many cases of malnutrition occurring in pig-feeding. It is interesting, in this connection, to note that cottonseed-meal has been found to produce in pigs a disease characterized by breathlessness, loss of appetite, and coarse hair, and that the addition of iron to the food prevents the disease.

Feed Fish-meal to Swine for Iodine.—"Some recent work done in America by Smith and others shows that iodine, though required only in small amounts, is of as great importance for health as lime and phosphorus. In Montana and certain other regions in the United States, and in some parts of Western Canada, great loss has been caused through sows giving birth to young pigs not fully developed. These were either dead at birth or lived only a short time. The most obvious abnormality was absence of hair. An examination of the food from affected and unaffected districts showed that the foodstuffs grown in the affected districts contained, on an average, less iodine than those grown in districts where the disease did not occur. The effect of adding iodine to the food was tried, and it was found that the addition of 5 grains of potassium iodide per day to the ration of each sow, for the last four or five weeks of the gestation period, led to the production of healthy litters from sows that previously had all had immature pigs. The amount of iodine required for the pig is unknown, so that it is impossible to say whether the disease was due to deficiency of iodine or to abnormality of the thyroid gland. The essential fact, however, is that addition of iodine to the food can prevent the disease.

Pigs need Good Pasture.—"The well-known beneficial effect of feeding ashes to pigs is due to the fact that the ashes contain minerals often deficient in their food. Wood-ashes may contain as much as 50 per cent. of lime, and coal-ashes as much as 5 per cent. of iron. The rooting-habit of the pig and also its liking for grubbing in the manure-pit are doubtless associated with its need for mineral matter. The well-recognized beneficial effects on the health of pigs of allowing them a free range over pasture is largely due to the fact that the animals have liberty to supplement the mineral deficiences of their food."—*Dr. J. B. Orr, Rowett Institute, Aberdeen.*

Fish-meal produces Increased Gains in Pigs.—"Experiments carried out here by Mr. A. D. Husband, A.I.C., have shown that a pig of three to four months old can absorb and retain as much as 5 grams of lime (CaO) per day. This mineral is required in the food to the extent of 1 to 2 per cent. of the increase in weight, and growth is limited if the supply in the food is not sufficient. Grains are deficient in lime. Shorts contain only 0.08 per cent. and corn less than 0.02 per cent. A pig putting on 2 lb. per day would require to eat over 20 lb. per day of a mixture of equal parts of these to get sufficient lime, whereas ¼ lb. of fish-meal would yield more than sufficient. It is not to be wondered at, therefore,

that the addition of fish-meal to a ration of grains and grain-offal leads to increased gains in weight.

Mineral Content of Fish-meal Important.—"The results of experiments carried out in connection with mineral requirement led us to believe that the undoubted beneficial effects of fish-meal in growth were largely dependent on the minerals present. To test this an experiment was carried out comparing fish-meal with blood-albumin (almost pure protein) to which mineral matter similar to that in fish-meal had been added. It was found that the ration with blood-albumin plus minerals gave as good results as fish-meal, but that with blood-albumin alone, although for the first fortnight the gains were as good as with fish-meal, afterwards growth slowed down and was no better than with a purely grain ration.

Balance the Swine Ration.—"The amounts to feed: No fixed rule can be stated in terms of a fraction of a ration, as a guide to the proper amounts to give. That depends on the nature of the other foodstuffs being fed and what the animal is producing. For a growing animal producing new tissue the proportion of protein to the other energy-yielding constituents of the ration (i.e., nutritive ratio) should be about 1 to 4 or 5 for young animals, and 1 to 6 or 7 for animals reaching maturity. A mixture of common meals and grains like sharps, barley, and maize has a protein ratio of about 1 to 7 or 8. For such a mixture, only a small amount of fish-meal is required to yield the requisite proportion of protein. A ration of the following proportions would be about right to give a ratio of 1 to 5:—

Simple and Cheap Rations.

	Proportion.
Shorts	100
Corn	100
Barley	100
Fish-meal	15

With foodstuffs containing less protein, such as corn and potatoes, more fish-meal would be required. A ration of:—

	Proportion.
Corn	100
Potatoes	300
Fish-meal	27

would give a ratio of about 1 to 5.

Reduce Quantity of Fish-meal at Finishing Period.—"The proportion of protein required decreases as the animal approaches maturity, so that the proportion of fish-meal in the ration should be steadily reduced until, when the animal is chiefly laying on fat, it is no longer required and is not economical to feed, since the cheaper starchy foods are better fat-formers than the more expensive protein foods."—*Orr, Crichton, and Green, Rowett Institute.*

Danger at Weaning.—"*The weaning period is truly the dangerous one*—that period when the little pig leaves the mother's milk and all too frequently is abruptly changed to a ration far different and far from what his system requires. This change should be made gradually, commencing about five weeks of age, the youngsters being taught to eat in a creep, which excludes the mother sow. At weaning-time, by increasing the food of the young pigs and removing them for longer periods daily from their mother, the shock to the system of the abrupt change of ration is greatly lessened. More good litters are ruined by the results of improper feeds and feeding by ill-defined methods at the period mentioned, and more swine-feeders thereby baffled and discouraged, than during any other phase of the pig's existence. The first feed for the little pig, when he is learning to eat and while nursing with the mother, should be made up of a few handfuls of dry grain scattered in the bedding. Crushed oats is excellent. By this is meant rolled oats, where such may be procured. Place in the creep a little trough containing milk."—*Rothwell.*

Milks compared.—The milk referred to will be cow's milk, of course, either skim- or butter-milk. Now it happens that cow's milk is quite a different product from sow's milk, as the following table shows:—

TABLE No. 18.

	Cow's Milk.	Sow's Milk.
	Per Cent.	Per Cent.
Protein	3.500	6.700
Calcium	0.161	0.395
Phosphorus	0.189	0.357
Ash	0.720	1.030

Supplement Cow's Milk with Fish-meal.—Figuring it another way, 1 gallon of cow's milk would contain 0.35 lb. protein, while 1 gallon of sow's milk would contain 0.67 lb. protein. It has been very well established that the rate of growth of a young animal depends upon the percentage of protein, calcium, and phosphorus in the milk of the species. It is impossible, therefore, for a little pig to maintain his usual rate of growth when put on a diet of cow's milk, but a simple modification of cow's milk overcomes the objection. The method of modifying cow's milk for little pigs is simply this:—

Cow's Milk and Fish-meal Ideal Combination.

To 1 gallon of cow's milk, which contains 0.35 lb. protein,
Add ½ lb. of pilchard-meal, which contains 0.33 lb. protein.

0.68 lb. protein.

Add them together and you then have 1 gallon of milk containing 0.68 lb. protein, or milk containing 6.8 per cent. protein, which is the same strength as sow's milk, for all intents and purposes.

Besides having added the required additional amount of protein, we have also added calcium and phosphorus in just the right proportion to form bone, for fish-meal contains these bone-forming minerals to the extent of as much as 12.50 per cent.

Oatmeal Good Feed for Pigs.—Small quantities of wheat shorts or wheat middlings plus oat middlings, equal parts, should be added to the modified milk. The quantity of these cereal by-products should be gradually increased until about the twelfth week, when coarser, and less expensive, feeds, such as oat-chop, barley-chop, ground wheat, etc., are substituted a little at a time, until a complete change-over is made. Green feed such as fresh-cut alfalfa or clover should be provided at all times, but if such be not available pulped roots should be part of the ration.

Good Growing Ration with Fish-meal.—Having passed the weaning period and, incidentally, having also passed the period when adequate quantities of milk are available—as so often happens—the following ration may be fed:—

200 lb. wheat shorts.
200 lb. oat-chop (or barley-chop).
100 lb. clover or alfalfa hay (pulverized).
50 lb. pilchard-meal.

Fish-meal-fed Pigs grade Higher.—Some of the finest Yorkshire pigs which have ever been raised in the Fraser Valley have been raised on the above ration, to which was added small quantities of potatoes and mangels. Practically all of the pigs raised on this ration graded as "selects," and this is a notable feature of a well-balanced ration containing fish-meal. It may be of interest to note that the above ration contains 18.8 per cent. crude protein and the nutritive ratio is 1 : 5.3, or just about what a good growing ration should be.

Fish-meal Ideal Supplement for Grain.—"The results of experimental work at this institute in connection with the mineral requirements of animals showed that the large amount of bone-forming material in *fish-meal* makes it suitable for mixing with grains and certain other commonly used feeding-stuffs which are deficient in this essential."—*Orr, Crichton, and Green.*

Proportion of Lean to Fat.—" It is essential, in both pork and bacon carcasses, that there should be an adequate proportion of lean to fat, which demands careful adjustment of the ration to provide protein of efficient quality and quantity, as it is from this constituent that lean meat is largely derived.

Proper Balance Essential.—" The nutritive ratios suitable in rations for pigs of varying conditions are as follows:—

Service boars	1 : 5.
Sows in-pig	1 : 5.
Sows in-milk	1 : 4 to 1 : 5.
Pigs from weaning to 16 weeks	1 : 5.
Fattening pigs	1 : 6 to 1 : 7.

Popular Ration contains Fish-meal.—" A nutritive ratio of about 1 to 5 is of general utility in pig-feeding, and it is to this reason that the so-called standard ration of 65 parts barley-meal, 25 parts shorts, and 10 parts fish-meal owes much of its popularity, as pig-feeders have found it simple to use in practice, the results obtained from it are of high standard, and it can be adjusted easily to narrower or wider ratios. For convenience, and in order to avoid confusion in the mind of the pigman, it is advisable to have no more alteration of rations than is demanded by economy. The ration of the in-pig sow should have a nutritive ratio of about 1 : 5, which should be narrowed somewhat as the sow approaches farrowing, and also for the suckling period. Although the 65–25–10 mixture may be used, it is more convenient to construct a ration which will cover the farrowing and nursing periods, and which will, at the same time, be suitable for the little pigs. A ration for this purpose . . . is as follows:—

	Per Cent.
Barley-meal	40
Sharps (shorts)	40
Linseed-cake meal	10
Fish-meal	10

Be sure to feed Roots or Alfalfa to Pigs.—" This represents an excellent ration for milk production and is very suitable for little pigs. The sows should receive a little green food or roots along with it. This ration is also suitable for service boars.

Simple Rations that are Economical.

	Per Cent.
For in-pig sows—	
Barley-meal	45
Sharps (shorts)	45
Fish-meal	10
For suckling sows—	
Barley-meal	45
Sharps (shorts)	35
Bean-meal	10
Fish-meal	10

" After weaning, the following ration is quite suitable for all classes of pigs:—

	Per Cent.
Barley-meal	65
Sharps (shorts)	25
Fish-meal	25

" Many variations of this may, of course, be constructed, of which the following is recommended:—

	Per Cent.
Barley-meal	60
Sharps (shorts)	20
Linseed-cake meal	10
Fish-meal	10

"During the last two or three weeks of feeding for pork, the fish-meal may be reduced to 5 per cent.

Produce "Selects" with Fish-meal.—"For bacon-pigs the same ration is quite suitable up to the last month of feeding, when the pigs should be finished on a mixture such as the following:—

	Per Cent.
Barley-meal	70
Sharps (shorts)	20
Bean-meal	10

Pea-meal may replace bean-meal.

Pigs are susceptible to Sudden Changes.—"In connection with the feeding of pigs, it is important to avoid any set-back when the pigs are weaned, as the animal which is allowed to go back at this critical period recovers lost ground slowly. It should be remembered also that there is no animal more susceptible to sudden changes of diet than is the pig. In the writer's experience, change, even from a poor ration to a good one, if carried out abruptly, results in retardation of growth and often in actual temporary loss of weight. A further point of practical interest is that wet-fed meals should not be sloppy, but should be rather of the consistency of porridge."—*Corrie.*

SWINE-FEEDING AND QUALITY OF PORK.

Fish-meal vs. Digester Tankage as Protein Supplement for fattening Swine.

Fish-meal proven Better than Tankage.—"At the suggestion of one of the leading manufacturers of fish-meal, a feeding trial was made to compare fish-meal with digester tankage as a protein supplement for fattening swine. In this trial, recently completed, we used twenty-four pigs which were divided into two comparable lots and fed for eighty-five days from self-feeders, free-choice, on shelled corn, protein supplement, and mineral mixture. For Lot 1 the protein supplement consisted of a standard '60-per-cent.' digester tankage manufactured by one of the largest packing concerns of the country; for Lot 2 'Atco' fish-meal, manufactured by the Atlantic Coast Fisheries Corporation of New York City, was used as the supplement.

Tankage and Fish-meal Comparisons.

	Tankage, Lot 1.	Fish-meal, Lot 2.
	Lb.	Lb.
Average starting weight	109.20	106.90
Average gain per animal after 57 days' feeding	99.10	123.30
Average gain per animal after 85 days' feeding	149.60	167.70
Average feed-consumption per animal during first 57 days—		
Corn	386.30	417.00
Supplement	37.90	37.40
Mineral	0.67	0.58
Average feed-consumption per animal during entire 85 days—		
Corn	591.50	642.50
Supplement	54.10	51.10
Mineral	1.13	1.00
Theoretical value of protein supplement per ton for first 57 days	$113.35	$202.76
Theoretical value of protein supplement per ton for entire 85 days	$114.55	$150.38

Merit of Fish-meal shows up in Two Months.—"In this test the animals were weighed individually every two weeks during the experiment. In the above tabular summary the weights for the beginning of the experiment are given together with the gains after fifty-seven days, at which time they were probably at their best weight for slaughter. The feeding test was continued for an additional length of time, not generally practical under actual farm conditions, so as to obtain certain extra information. We consider the results

for the fifty-seventh day as more significant than those for the eighty-fifth day so far as practical applications are concerned.

Fish-meal-fed Pigs are ahead of those fed Tankage.—" The results show that at the close of the test the pigs receiving fish-meal were nearly two weeks ahead of those receiving tankage. On the seventy-first day the average weight for Lot 1 was 237.8 lb. and for Lot 2 was 253.4 lb. Two weeks later Lot 1 was 258.8 lb., only about 5 lb. more than Lot 2 had weighed two weeks previously.

Fish-meal stimulates Appetite.—" The values given at the bottom of the table were obtained by figuring corn at 1¾ cents per pound, mineral mixture at 1 cent per pound, and the hogs at 9 cents per pound. It will be noted that the animals in Lot 1 consumed more mineral mixture and more of the protein supplement than did those in Lot 2. Apparently the fish-meal stimulated the appetite for corn as more was consumed in Lot 2.

Good Carcass obtained.—" All carcasses graded as ' hard " and no tendency toward softness in either lot was observed. Leaf-fat samples were taken and tested at 40° C. for refractive index. Composite samples of those gave refractive indices of 1.4590 for Lot 1 and 1.4592 for Lot 2. This difference is so small as to be negligible and without significance. Therefore it appears that either tankage or fish-meal can be used satisfactorily in producing hard pork and there is no important difference between the two in this respect.

Judging Meat for Flavour.—" Samples of the meat were taken for cooking to be judged as to flavour. It was especially desired in this to determine whether or not fish-meal imparts a fishy flavour or odour to the meat. This part of the work is reported below.

Effect of Fish-meal on Flavour of Pork.

Fish-meal fed to Day of Slaughter.—" Samples of meat were taken from hogs that had been self-fed on corn and fish-meal and on corn and tankage for eighty-five days. The samples were from the top of the shoulder, what is known in the meat trade as a ' Boston butt.' The hogs had received their feed until about twenty-four hours before slaughter.

Fifteen Judges say no Taint from feeding Fish-meal.—" These samples were prepared by baking in a commercial bakery oven for about one and three-quarter hours at about 600° F. and were then judged by fifteen persons to determine whether or not any fishy flavour or odour had been imparted to the meat by the fish-meal. The samples from the animals not receiving fish-meal were employed in this test as a ' check.' They were from pigs that had received a standard 60-per-cent. protein digester tankage.

" The results showed that this fish-meal had not imparted a fishy flavour or odour to the meat of the hogs consuming it. None of the judges could detect any fishy odour or flavour in any of the samples. We conclude from this that fish-meal does not affect the flavour or odour of pork when fed to swine."—*F. R. Edwards, Animal Husbandman, Georgia State College of Agriculture.*

SKIM-MILK *VERSUS* FISH-MEAL FOR MARKET HOGS.

(Dominion Experimental Farm, Project A. 571, Agassiz, B.C.)

" High-grade wholesome edible fish-meal has become a popular feed for poultry in British Columbia. It is also used with considerable success for hog-feeding. In an experiment covering a period of 120 days it was compared with skim-milk as a supplement to the grain ration; forty uniform hogs being divided into eight equal lots for this purpose. The pigs used were pure-bred Yorkshire sows and barrows and averaged ten weeks old when started. A grain ration as follows was fed all lots for the first sixty days: 1 part bran, 2 parts ground barley, 4 parts shorts, 4 parts oats, and 4 per cent. oil-meal. This ration cost 1.663 cents per pound. For the second period the ration was made a little stronger by using 4 parts barley and only 2 parts shorts, the cost being 1.733 cents per pound. The pigs were confined in small pens throughout the trial, milk was fed at from 6 to 8 lb. per pig per day and charged

at 25 cents per 100 lb., while fish-meal cost $70 per ton and was fed at the rate of 7 per cent. of the meal ration.

Various Rations tried out.

SCHEDULE OF FEEDING.

Lot 1—Meal ration and skim-milk throughout experiment.
Lot 2—Meal ration and 7 per cent. fish-meal throughout experiment.
Lot 3—Meal ration and skim-milk to July 10th; then replace with fish-meal to finish.
Lot 4—Meal ration and skim-milk to July 10th; then meal only to finish.
Lot 5—Meal ration and skim-milk to August 11th; then replace milk with fish-meal to finish.
Lot 6—Meal ration and skim-milk to August 11th; then meal only to finish.
Lot 7—Meal ration and skim-milk to September 17th; then replace milk with fish-meal to finish.
Lot 8—Meal ration and skim-milk to September 17th; then meal only to finish.

ANALYSIS OF FISH-MEAL FED.

	Per Cent.
Moisture	7.25
Protein	69.38
Fat	12.48
Ash	10.14
Phosphate of lime	7.58

SKIM-MILK VERSUS FISH-MEAL.

Lot.	Weights.						Total Gain.	Total Cost of Feed.	Cost per Cwt. Gain.
	June 21.	July 10.	Aug. 11.	Aug. 21.	Sept. 18.	Final, Oct. 19.			
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	$ cts.	Cents.
Lot 1	202	314	510	589	775	907	705	43.18	612.48
Lot 2	205	294	473	530	753	972	767	48.13	627.51
Lot 3	205	323	485	551	717	960	755	49.11	650.46
Lot 4	200	299	390	420	641	791	591	35.82	606.09
Lot 5	204	312	480	533	700	990	786	50.60	643.77
Lot 6	207	313	498	543	610	746	539	35.92	666.42
Lot 7	202	307	498	571	740	912	710	46.91	660.70
Lot 8	205	321	505	586	745	640	640	39.63	619.22

Fish-meal produces Biggest Gains.—*"The results secured give strong evidence in favour of fish-meal as a gain-producer. In each instance the fish-meal-fed hogs made greater gains than those getting a similar ration, with fish-meal eliminated.* Comparing Lot 1 and Lot 2, skim-milk gave the greatest growth for the first half of the period and then the fish-meal gradually caught up and finished well in the lead. Comparing Lot 3 and Lot 4, each got milk to July 10th and Lot 3 with fish-meal to finish gave much the better gains. Lot 4 never did well; one pig being crippled for a time was given milk for the first twenty days in September in an endeavour to bring it back to normal. Comparing Lot 5 and Lot 6, while these pens were getting milk, Lot 6 made greater gains, but when the milk was discontinued they went off feed several times, and Lot 5 getting fish-meal made much faster gains. The same is true of Lot 7 and Lot 8, although the final difference in weights was not so great owing to shortness of feeding period.

"Although fish-meal gave good results in gain production, it did not show up so well when costs were considered. In each instance where fish-meal was fed the costs were higher, except with Lot 5. This advantage in cost in favour of the fish-meal is due to the fact that Lot 6 went off feed.

" Briefly, the evidence in this one trial is that fish-meal is valuable in producing rapid gains in market hogs, but at $70 per ton is a little too expensive."—*Taken from Annual Report, 1926, Experimental Farm, Agassiz, B.C.; W. H. Hicks, B.S.A., Superintendent.*

Comment on Project A. 571, 1926, at Agassiz.

Judging from the analysis of the fish-meal used in this experiment, it would appear that this was made from grayfish or dogfish, as the protein content is somewhat higher than is usually found in pilchard-meal, which, on the other hand, carries a higher percentage of ash.

Acid-alkali Balance required in Swine Ration.—It should also be pointed out that a diet of cereals and cereal by-products plus fish-meal is distinctly acid-forming, whereas substituting skim-milk for fish-meal makes a superior acid-alkali balance. In balancing a ration for swine it is just as important to look to the acid-alkali balance as it is to make sure that the protein-carbohydrate balance is correct. There is no doubt that had these pigs which received fish-meal been on pasture, or been supplied grass, roots, or other alkaline foods, they would have made even a better showing than they did, and, further, the cost of producing a pound of pork would have been materially reduced.

Other Feeding Tests compared.—A number of hog-feeding demonstrations which have been carried out in Iowa and elsewhere (data on which need not be quoted here) show that fish-meal is the most economical protein supplement for swine, but in all these United States demonstrations the high acidity of a cereal-meat diet is offset by the addition to the ration of either alkaline foods or minerals.

MINERAL *VERSUS* COD-LIVER OIL.

(Dominion Experimental Farm, Project A. 496, Agassiz, B.C.)

" In January twenty uniform pigs were divided into five equal groups to be finished, with the object in view of determining the value of minerals and cod-liver oil as supplements to a grain and milk ration. The grain ration consisted of 4 parts shorts, 2 parts ground oats, and 1 part corn-meal, and cost 1.657 cents per pound. The pigs were fed what they would clean up at all times. Equal quantities of milk were given each lot. The mineral mixture was fed at the rate of 3 per cent. of the grain ration and was made up of the following: Ground bone-meal, 8 lb.; ground charcoal, 5 lb.; ground rock phosphate, 5 lb.; salt, 3 lb. Cod-liver oil was mixed with the feed and fed at the rate of ¼ oz. per pig per day.

Pig-feeding Experiment—Minerals versus Cod-liver Oil.

	Lot 1, Grain, Milk.	Lot 2, Grain, Milk, Cod-liver Oil, Mineral.	Lot 3, Grain, Milk, Mineral.	Lot 4, Grain, Milk, Cod-liver Oil.	Lot 5, Grain, Milk, Cod-liver Oil, Ashes.
Number of pigs in each group	4	4	4	4	4
Total weight, January 20 lb.	231	225	229	230	231
Total weight, April 20 ,,	600	755	570	765	775
Total gain in weight in 90 days ,,	369	530	341	535	544
Average gain per pig per day ,,	1.025	1.472	0.947	1.486	1.511
Feed consumed.					
Pounds of grain at 1.657c. per pound ,,	1,240	1,752	1,128	1,673	1,732
Pounds of milk at 25c. per 100 lb. ,,	1,925	1,925	1,925	1,925	1,925
Pounds of mineral mixture at 2.7c. per pound ,,	.....	56	36	.....	.....
Ounces of cod-liver oil at 1.5c. per ounce oz.	.....	90	.....	90	90
Total cost of feed consumed $	25.38	36.70	24.47	33.88	34.86
Feed cost to produce 1 lb. gain cts.	6.878	6.924	7.1759	6.333	6.408

Results are Inconsistent.—" The results show cod-liver oil valuable as a hog-feed. The three lots getting cod-liver oil made the greatest gains; Lot 5 getting ashes and oil gave the best gains. Lot 3 with mineral only, added to the milk and grain ration made very poor gains, even less than Lot 1 without a supplement. This is contrary to results obtained previously. Not only did the cod-liver-oil-fed lots make good gains, but the gains were cheap, except Lot 2, which consumed so much meal that the cost of 100 lb. gain was greater than with Lot 1."—*Taken from Annual Report of 1926, Experimental Farm, Agassiz, B.C.; W. H. Hicks, B.S.A., Superintendent.*

Comment on Project A. 496, 1926, at Agassiz, B.C.

It is difficult at times to find an explanation for the results obtained when certain supplements are added to a ration, whether it be for pigs or other animals. The main difficulty is brought about by the presence of what might be classed as impurities in the supplement. Beneficial results from the feeding of cod-liver oil to domestic live stock are frequently due to the presence of iodine in the oil. In the above test it is likely that iodine played an even greater part than any vitamins which might have been present in the oil.

The following report by Dr. Orr of some work done by Crowther is therefore particularly interesting in connection with the work done by Hicks at Agassiz:—

" Crowther has carried out some practical feeding experiments which are of interest in the present connection. He was testing the value of certain feeding-stuffs for pigs, and included fish-meal and cod-liver oil in his tests.

Cod-liver Oil and Fish-meal compared.—" A control group were fed with bran, shorts, and barley-meal, with no additions. A second group had cod-liver oil added to the extent of ½ oz. per pig per day. In a third group part of the barley-meal was replaced by fish-meal to an extent which made the fish-meal constitute 11¼ per cent. of the whole ration.

Results obtained.—" The following results are taken from a table given by Crowther:—

	Live Weight Increase in 68 Days.	Weight of Food consumed per Pound Live Weight Increase.
Cereal ration	61.0	4.58
Cereals, cod-liver oil	64.9	4.54
Cereals, fish-meal	86.6	3.82

Cereals proven deficient in Minerals.—" Cereal grains are deficient in mineral matter, and the addition of oil, as stated above, increases the assimilation and retention of minerals, and so improves the rate of growth; but the *fish-meal,* which is rich in mineral matter, though containing little or no vitamin, shows a much better result with regard to rate of growth and profitable gains in weight than the vitamin-rich cod-liver oil.

Vitamin Content adequate.—" Crowther concludes that the results ' indicate no lack of " fat-soluble vitamin " in the cereal-meal ration, since any deficiency would have been remedied by the cod-liver oil, which would then have caused a marked improvement in the rate of growth, and a decided fall in the weight of food required to produce 1 lb. of live-weight increase.' And later: ' The more effective utilization of food obtained by the use of fish-meal must therefore have been due to some factor other than vitamin-supply.' This other factor, as the present writers (Orr and Crichton) have shown, is the rich mineral and protein content of the fish-meal.

Vitamin-supply not Important.—" From the results of these and other experiments not referred to here, Crowther gives as his opinion that ' it would seem very doubtful whether for a great part of our pig-feeding practice the " vitamin " supply is of such practical importance as some popular expositors of this fashionable dogma would have us believe.' "

EXPERIMENTAL FEEDING.

Fish-meal versus Skim-milk at Nappan, N.S.—A continuation of the skim-milk *vs.* fish-meal experiment, as outlined in the 1927 report, was carried on during the winter of 1927–28.

In the first experiment thirty-five pigs were used in seven pens of five each. Pen 1 received skim-milk from weaning to finish; Pen 2, skim-milk to three months, then fish-meal; Pen 3, same as 2, only fish-meal started at four months; Pen 4, same as 2, only fish-meal started at five months; Pen 5, skim-milk to three months, then grain only; Pen 6, skim-milk to four months, then grain only; and Pen 7, skim-milk until five months, then grain only.

The second test consisted of two pens of five pigs each, all from one litter. Pen 8 received skim-milk from weaning to finish and Pen 9 fish-meal in place of skim-milk.

In all cases the fish-meal was fed at the rate of 8 per cent. of the meal mixture.

Fish-meal produces Select Bacon-hog.—*The results of these experiments to date would indicate that fish-meal makes a very desirable substitute for skim-milk, and where the latter is not available it might well be used to supply the animal protein necessary in the development of the select bacon-hog. The grading results show a higher percentage of selects from the fish-meal-fed groups,* while the group receiving no animal protein for a greater part of the feeding period did not develop as rapidly and consequently show a high percentage of shop-hogs. These experiments will be continued.

Following are the results of the experiments for 1928:—

SKIM-MILK VS. FISH-MEAL FOR PORK PRODUCTION—WINTER, 1927–28.

		Pen 1.	Pen 2.	Pen 3.	Pen 4.	Pen 5.	Pen 6.	Pen 7.
Hogs in test	No.	5	5	5	5	5	5	5
Initial gross weight	lb.	167	166	168	167	163	113	113
Initial average weight	,,	33.4	33.2	33.6	33.4	32.6	22.6	22.6
Days on test	No.	173	173	173	173	173	173	173
Finished gross weight	lb.	928	947	956	925	856	725	744
Finished average weight	,,	185.6	189.4	191.2	185.0	171.2	145.0	148.8
Total gain for period	,,	761	781	788	758	693	612	631
Average gain for period	,,	152.2	156.2	157.6	151.6	138.6	122.4	126.2
Average daily gain per hog	,,	0.88	0.903	0.911	0.876	0.801	0.708	0.729
Total meal consumed	,,	2,600	2,600	2,600	2,600	2,600	2,400	2,400
Total roots consumed	,,	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total skim-milk consumed	,,	4,200	400	400	400	400	1,450	2,150
Total fish-meal consumed	,,	.....	180	160	130	.....	.....	.....
Total mineral mixture consumed	,,	126	126	126	126	126	126	126
Meal consumed per pound gain	,,	3.42	3.33	3.30	3.43	3.75	3.92	3.80
Total cost of feed	$	73.09	71.34	70.69	69.71	65.49	62.99	64.39
Average cost of feed per hog	$	14.62	14.27	14.14	13.94	13.10	12.60	12.88
Cost of feed per hog per day	cts.	8.45	8.25	8.17	8.06	7.57	7.28	7.45
Cost of feed per pound gain	,,	9.60	9.13	8.97	9.20	9.45	10.29	10.20
Feed Prices used.								
Meal	$2.30 per cwt.							
Roots	7.25 per ton							
Skim-milk	4.00 ,,							
Fish-meal	65.00 ,,							
Mineral	20.00 ,,							

Fish-meal at $65 per Ton cheaper than Milk at $4 per Ton.

SKIM-MILK VS. FISH-MEAL FOR PORK PRODUCTION—WINTER, 1927–28.

		Pen 8, Skim-milk Weaning to Finish.	Pen 9, Fish-meal Weaning to Finish.
Hogs in test	No.	5	5
Initial gross weight	lb.	119	120
Initial average weight	„	23.8	24
Days on test	No.	209	209
Finished gross weight	lb.	968	974
Finished average weight	„	193.6	194.8
Total gain for period	„	849	854
Average gain for period	„	169.8	170.8
Average daily gain per hog	„	0.812	0.817
Total meal consumed	„	3,177	3,177
Total roots consumed	„	1,245	1,245
Total skim-milk consumed	„	5,210	.....
Total fish-meal consumed	„	.....	238
Total mineral mixture consumed	„	115	115
Meal consumed per pound gain	„	3.74	3.72
Total cost of feed	$	89.15	86.47
Average cost of feed per hog	$	17.83	17.29
Cost of feed per hog per day	cts.	8.53	8.27
Cost of feed per pound gain	„	10.50	10.13

Feed Prices used.

Meal	$2.30 per cwt.
Roots	7.25 per ton
Skim-milk	4.00 „
Fish-meal	65.00 „
Minerals	20.00 „

GRADING OF HOGS IN FEEDING EXPERIMENTS, 1928.

	Lot 1.	Lot 2.	Lot 3.	Lot 4.	Lot 5.	Lot 6.	Lot 7.	Lot 8.	Lot 9.
Select bacon	3	4	2	2	....	2	....	3	4
Thick smooth	....	....	2	1	2	....	....	1	....
Shop-hogs	2	1	1	2	3	3	5	1	1

AVERAGE OF 1927–28 EXPERIMENTS.

Treatment.	Grading.					
	Select Bacon.		Thick Smooth.		Shop-hogs.	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Skim-milk from weaning to finish	14	70	3	15	3	15
Skim-milk to 3 mos.—fish-meal to finish	13	87	....	....	2	13
Skim-milk to 3 mos.—fish-meal after 4 mos	9	60	3	20	3	20
Skim-milk to 3 mos.—fish-meal after 5 mos	6	40	6	40	3	20
Skim-milk to 3 mos.—then grain only	5	33	5	33	5	33
Skim-milk to 4 mos.—then grain only	7	47	2	13	6	40
Skim-milk to 5 mos.—then grain only	3	30	....	....	7	70
Fish-meal from weaning to finish	4	80	....	....	1	20

(Taken from Annual Report for 1928, Experimental Farm, Nappan, N.S.; W. W. Baird, B.S.A., Superintendent).

Fish-meal used in East and West.—In this experiment at Nappan, N.S., results were somewhat similar to those obtained at Agassiz. Here, though, the hogs on fish-meal graded out better than others receiving no fish-meal; and this is in line with results obtained by hog-feeders in many parts of British Columbia. No doubt the protein of fish-meal tends to produce a fine grade of lean meat on the hog, and the mineral matter in fish-meal tends to develop the skeleton to its limit, thereby producing a longer, smoother hog than might be the case otherwise.

Include Roots or Grass in Ration with Fish-meal.—You will notice that at Nappan some attempt has been made to bring about an acid-alkali balance in the ration by the addition of roots, which are alkaline.

Mineral Supplements not required with Pilchard-meal.—You will also notice that at Nappan a " mineral mixture " was fed, evidently in such a way that the pigs had no choice but to consume it, as the consumption in Pens 1 to 7 is identical and the same is true of consumption in Pens 8 and 9. In experiments at other farms and stations " mineral " consumption is generally less when fish-meal is fed owing to the high mineral content of all fish-meal except that made from grayfish (dogfish), which is a non-bony fish. There would, however, be some advantage in feeding a mineral mixture with fish-meal provided it was high in alkaline minerals such as calcium, which, to some extent, would bring about an acid-alkali balance such as the feeding of roots, clover, or alfalfa would do. Alfalfa (fresh cut) would have many other advantages besides supplying calcium and should be fed wherever it is possible.

FISH-MEAL *VERSUS* SKIM-MILK FOR PORK PRODUCTION.

Results at Nappan, N.S., for Five Years.—At the Dominion Experimental Farm, Nappan, N.S., for the past five years, comparative tests have been made of fish-meal and skim-milk for raising bacon-hogs.

Comparative Gains.—" Averaging the results of all experiments, it was found that the hogs fed fish-meal gained 1.01 lb. per day, those on skim-milk 0.985 lb., and the check-lots 0.907 lb. In 1926 the average daily gains were as follows:—

	Lb.
Fish-meal	1.25
Skim-milk	1.10
Check-lot	0.93

More " Selects " when fed Fish-meal.—" In all the experiments outlined the hogs in the fish-meal-fed lots were equally as good as or better in type and finish than those fed skim-milk, and both lots showed marked superiority over the check-lots. The 1927 fed hogs were graded by a representative of the Live Stock Branch and the results were as follows:—

Fish-meal group, 90 per cent. selects, 10 per cent. shop-hogs.

Skim-milk group, 80 per cent. selects, 20 per cent. thick smooth.

Check group, 50 per cent. selects, 30 per cent. thick smooth, 20 per cent. shop-hogs."

Six to Eight per Cent. Fish-meal advocated.—The conclusion drawn was that " Fish-meal analysing 70 per cent. total protein or 63 per cent. digestible protein is one of the cheapest protein feeds on the market at the present time, and if fed at the rate of 6 to 8 per cent. of the meal ration will give good gains and develop a good type and well-finished bacon-hog, providing a balanced ration is fed."

PART III.—POULTRY.

Fish-meal in Poultry Rations.—The feeding of fish-meal to poultry in the Pacific Coast States (California, Oregon, and Washington) as well as in British Columbia is an old-established practice. In the Fraser Valley and on Vancouver Island, where poultry are kept on the intensive system, it would be difficult to find a flock which does not regularly receive fish-meal in the mash ration. From our experience, however, hardly any two flocks are being fed exactly similar rations, but, on the other hand, results are strikingly similar; that is, a poultry ration containing fish-meal in preference to beef-scrap, meat-meal, etc., gives superior production of either eggs or meat at less cost.

Pilchard and Dogfish Meal both used.—Previous to 1925–26 the fish-meal ordinarily used in British Columbia was made from grayfish (dogfish) containing as much as 70 per cent. protein and about 7 or 8 per cent. of mineral ash. Since this date, however, the use of pilchard-meal has become general even though the percentage of protein is slightly lower, being from 62.5 to 65 per cent.; the percentage of mineral ash is correspondingly higher, being from 12 to 15 per cent., which is considered by most poultrymen to be some advantage.

Fish-meal in "All-mash" Rations.—Fish-meal may be fed when either the "all-mash" or mash-scratch methods of feeding are employed. In either case, however, the use of milling by-products such as wheat-bran, etc., is not advocated; mash rations consisting of ground grains such as wheat, oats, and barley being preferable to the usually recommended mashes made up with milling by-products. In buying ground grains preference should be given to those which have been prepared in mills of the "hammer" type. As pointed out by Holst, the use of a variety of grains is not necessary, which being the case, preference should be given to such grains as oats and barley which are produced locally. A ration of pulverized (hammered) oats plus fish-meal can be expected to give results equal to, if not superior to, one containing a variety of grains and cereal by-products. There was a time, before the advent of fish-meal, when a mixture of grains, etc., was an advantage, for by using a variety it was hoped that the deficiencies of the various cereal proteins would compensate each other to some extent; but since fish-meal proteins have been proven to be "complete" proteins the advantage of variety no longer need be considered.

Cod-liver Oil not Necessary with Fish-meal.—It has been frequently demonstrated that when the calcium-phosphorus balance of a ration is reasonably correct, the addition of such substances as cod-liver oil to the ration is quite unnecessary. Birds have been raised in "batteries" beyond the reach of sunshine on a ration containing only fish-meal as the protein, mineral, vitamin supply, and with results superior to those obtained with rations not containing fish-meal but containing cod-liver oil. The explanation for this is that fish-meal contains calcium and phosphorus in the correct proportion to form bone, and though the vitamin content of the oil in fish-meal is too small to measure by present standards, it is apparently sufficient to meet the needs of birds kept in confinement.

Keep Percentage Protein Low.—It has been pointed out by a number of investigators in poultry-nutrition that when the protein in a mash is of just the right quality, a much smaller percentage than popularly supposed will be found to meet the needs of even heavy-laying birds. Poultry mashes commonly used contain as much as 20 or 21 per cent. protein—derived from various sources, possibly with the old idea that there is safety in numbers or variety of sources. It would seem, therefore, that the maximum percentage of protein required when fish-meal is the sole source of protein would be about 17. If, under some conditions, this amount does not appear to be sufficient, a supply of fish-meal as it comes from the sack may be provided in a separate hopper, so that such birds as seem to require additional protein may be able to help themselves.

Form of Nutrients Important.—"In practical feeding it is not the separate nutrients which are dealt with, but feedstuffs which are mixtures of them. Neither are the nutrients present in pure form, but as so-called crude proteins, crude fats, etc. The fact that the nutrients are present in a mixture does not affect the underlying principles of nutrition, which govern each one of them separately. Of much more concern is the form in which they are present. This is of primary importance with proteins, carbohydrates, and fats."

TABLE NO. 18.—THE PER CENT. COMPOSITION OF FEEDSTUFFS USED IN DIGESTIBILITY TRIALS WITH POULTRY.

Use these Tables only for Poultry.

Feedstuff.	Moisture.	Minerals.	Organic Substance.	Crude Protein.	Nitrogen-free Extract.	Crude Fat.	Crude Fibre.
Barley	12.33	2.88	84.79	13.93	64.16	1.80	4.90
Corn	13.00	1.30	85.70	9.90	69.20	4.40	2.20
Fish-meal	*9.89*	*12.30*	*77.81*	*61.93*	*2.57*	*13.31*	.....
Meat-scrap	9.32	17.15	73.53	50.24	2.21	16.15	4.93
Potatoes	74.69	1.39	23.92	1.84	21.23	0.10	0.75
Rice, unpolished	11.65	1.72	86.63	10.45	73.52	1.93	0.73
Rice-bran	11.05	11.43	77.52	14.13	35.96	19.31	8.12
Rye	15.32	1.98	82.70	9.83	69.02	1.65	2.20
Soy-bean meal	10.79	6.21	83.00	42.68	28.76	7.23	4.33
Wheat	13.42	1.92	84.66	14.03	66.47	1.93	2.23
Wheat-bran	12.40	5.41	82.19	14.87	54.25	4.06	9.01
Yeast	8.73	6.66	84.61	55.44	26.44	2.73	0.50

TABLE NO. 19.—DIGESTIBILITY COEFFICIENTS FOR THE DIFFERENT NUTRIENTS OF COMMON FEEDSTUFFS FOR POULTRY.*

Poultry digest Fish-meal over 90 per Cent.

Feedstuff.	Organic Substance.	Crude Protein.	Nitrogen-free Extract.	Fat.	Crude Fibre.
Barley	75.4	75.1	82.2	48.0	0000
Corn	86.2	58.0†	93.0	8.53	0000
Fish-meal	*88.9*	*90.6*	.....	*98.2*	*0000*
Meat-scrap	76.6	73.6	.....	82.1	0000
Potatoes	78.3	46.9	84.5	.....	0000
Rice, unpolished	78.0	76.9	88.1	64.1	0000
Rice-bran	59.7	66.9	58.2	87.7	0000
Rye	79.2	63.0	85.6	28.5	0000
Soy-bean meal	76.6	83.4	75.3	84.1	0000
Wheat	84.3	78.9	89.3	39.8	0000
Wheat-bran	55.3	64.3	61.2	55.6	0000
Yeast	75.5	76.2	82.8	57.1	0000

* Figures in this, the preceding, and following table mainly from Katayama (1924), supplemented from Voltz (1909 and 1923).

† This figure was obtained by a different method which possibly gives it a somewhat lower figure.

TABLE No. 20.—POUNDS OF NUTRIENTS DIGESTIBLE TO POULTRY IN 100 LB. OF FEED.
(Based on Composition of Feeds as given in Table No. 18.)

Fish-meal better than Beef-scrap for Poultry.

Feedstuff.	Organic Substance.	Protein.	Nitrogen-free Extract.	Fat.
Barley	63.93	10.46	52.74	0.86
Corn	73.87	5.74	64.38	3.75
Fish-meal	*69.17*	*56.11*	*None*	*13.07*
Meat-scrap	53.03	36.98	(2.21)	13.24
Potatoes	18.73	0.86	17.94	.....
Rice, unpolished	74.05	8.04	64.77	1.24
Rice-bran	46.28	9.45	20.93	16.93
Rye	65.50	6.19	59.08	0.47
Soy-bean meal	63.58	35.61	21.65	6.08
Wheat	71.37	11.07	59.36	0.77
Wheat-bran	45.45	9.56	33.20	2.26
Yeast	63.88	42.25	21.89	1.56

"The proportions in which these nutrients are present can be accurately determined by analysis. Tables of the composition of feedstuffs give the average proportion of these classes of nutrients in the common feeds.

Digestibility varies with Different Species of Animals.—"Since different kinds of animals have marked differences in their digestive systems, the digestibility will vary for different species and has to be specially determined for each species (i.e., for cattle, horses, hogs, chickens, etc.). Because of the experimental difficulties, caused by the combined excretions of fæces and urine, work with chickens has been carried out only on a very limited scale. Outside of the few coefficients given in Table No. 19, figures have to be accepted with the greatest caution. Digestibility coefficients obtained in experiments with other kinds of animals, even with other species of poultry, positively cannot be applied to chickens; they are very misleading. No complete fundamental standards being available, feeding of poultry has to be based more or less on practical experience and knowledge of the composition of feeds.

COMPARISON OF QUALITY OF NUTRIENTS IN DIFFERENT FEEDS.

Quality of Nutrients compared.—"Not expressed in the digestibility coefficient and the nutritive ratio, but just as important if not more so, is the quality of the food protein. There is no fundamental difference between animal and vegetable proteins, provided these latter contain the essential amino-acids. There is, however, a difference between the efficiency of the two, because the vegetable cell membrane, being composed largely of non-digestible cellulose (crude fibre), hinders digestion of the included proteins, so that more energy is required for their digestion. Even considering this, there is sufficient difference in price to justify a more extensive use of the vegetable protein concentrates.

Different Qualities of Protein.—"Another point to consider is that, as indicated before, many of the grain proteins are lacking in one or more of the essential amino-acids. This deficiency is not the same in all of them, so that perfectly well-balanced proteins might be obtained by making the proper selection of grains alone. This is more practically accomplished, however, by introducing suitable protein concentrates, such as *fish-scrap,* meat-scrap, soy-bean meal, peanut-meal, etc., as supplements to the grains.

"Although the question of quality is thus of great importance in the case of proteins, with carbohydrates all digestible carbohydrates are equivalent. The digestible carbohydrates consist largely of starch.

Poultry easily digest Fish-oil.—"The fats of animal feeds are more easily digested by birds than those of vegetable feeds. This difference is not caused by any difference in composition, but is due to the fact that vegetable fats generally are less accessible to the digestive juices because contained in cells with cellulose walls.

Feed enough Minerals.—" There is no way of testing the digestibility of minerals. In order to determine definitely whether they are supplied in sufficient amounts, it is necessary to determine what is called the mineral balance. If more of a mineral is taken in with the food than is passed out in the combined excretions and eggs, the bird is said to be in positive balance; the reverse illustrates a negative balance. The effort is always made to feed at least enough minerals to get the intake as high as the outgo. In growing birds the intake must be higher than the outgo to allow for bone and tissue formation.

Quantity of Rarer Minerals Sufficient.—" With the exception of calcium, phosphorus, sodium, and possibly chlorine, the minerals are found in sufficient amounts in ordinary feeds. The quantities present are always small, but the needs are slight, so that special attention generally need be given only to the supply of the four elements just mentioned.

Do not feed Sulphur to Poultry.—" Although these four elements can be supplied in inorganic form, such as limestone, phosphates, and common salt, or tied up with organic matter, one element, sulphur, behaves differently. It has to be supplied in a particular form. This element cannot be used in the pure form by birds, but must be provided in certain proteins in which it appears as a constituent of the amino-acid called cystine.

Grains.—" The exact combination of grains is of slight importance. The separate kinds, and also the proportions of each kind, to be used at a time will depend largely upon price conditions.

Variety preferred but not Necessary.—" A variety of grains is always preferable, because it increases the palatability and therefore also increases food-consumption. A variety is, on the other hand, by no means necessary. Birds have repeatedly been raised and kept in good production by using one grain only *when it was properly supplemented.*

Fish-meal more Palatable than Beef-scrap.—" Fish scrap or meal is the dried product derived from the whole fish, such as dogfish or herring (or pilchard), and from the waste from canneries. Fish proteins are not very different from or superior to proteins of other animal products, but the fish products generally are manufactured at lower temperatures than the corresponding meat products. They are, as a consequence, more palatable and better digested than meat-scraps or tankage. An average fish-scrap which contains about 60 per cent. protein will have about 70 lb. of digestible nutrients to the hundred. It is usually worth about 30 per cent. more than a meat-scrap of the same protein content as shown by analysis. Unless the fat content is far above the average, which should be between 4 and 6 per cent., fish-scrap, even when fed in large amounts, does not under any circumstances give taste or odour to the eggs produced by flocks to which it is fed.

Lecithin.—" In addition, fish-scrap contains lecithin, an organic substance which is supposed to be very important, and certain desirable minerals, like iodine.

Buy Proteins on Unit Basis.—" Animal *versus* vegetable protein supplements. The question as to whether to use animal or suitable vegetable protein concentrates in feeding for growth and egg production should largely be decided by prices per unit of protein in the different products. A good practical rule is to introduce vegetable protein supplements into a poultry ration when the price per unit of digestible protein in the vegetable concentrates is at least 10 per cent. *less* than the corresponding animal protein. One should never be afraid of using the vegetable products, as there is no fundamental difference between the two classes. . . .

Animal Proteins improve Digestibility of Rations.—" While thus the protein may be supplied from vegetable sources only, there is one reason for always including a small quantity, say 4 or 5 per cent., of milk products, fish or meat scraps. These substances have the peculiar effect, on entering the glandular stomach, of causing a particularly strong flow of digestive juices, which must be assumed to cause a more rapid and complete digestion of the rest of the food. . . .

Include Minerals in Mash.—" Mineral supplements. Care should always be taken to ensure sufficient consumption of minerals. The best practice is, therefore, to include most

of the necessary mineral supplements in the mash. Growing and laying mashes should contain between 8 and 10 per cent. of minerals, a part of which should always consist of calcium carbonate, such as ground limestone. This will aid in the neutralization of organic and inorganic acids produced in the body.

Sources of Minerals for Poultry.—" A certain part of the minerals needed by the birds is naturally contained in the grain and protein concentrates in the ration. These products do not, however, provide sufficient sodium, calcium, phosphorus, chlorine, and iron, particularly for growing and laying birds. The deficient minerals can be easily and cheaply obtained; sodium and chlorine from common salt; calcium from limestone, clam-shell, ground marble, hydrated lime, etc.; phosphorus and calcium from fresh bones or bone-meal, acid phosphate, etc. The iron requirements are usually taken care of by the iron in the vitamin supplements. A possible iodine deficiency is overcome by using *fish-scrap* as a source of protein or by using oyster-shell for supplying calcium carbonate. . . ."

Clam-shell is preferred to Oyster-shell.—(In British Columbia, and elsewhere along the Pacific Coast, the use of oyster-shell as a source of calcium carbonate for egg-shell formation is no longer the common practice which it once was. It has been definitely established in feeding trials that clam-shell, of which their is an almost unlimited supply on the British Columbia Coast, serves the purpose equally well from a dietetic point of view —and at much less cost.)

Never use General Tonics for Poultry.—" Other minerals like sulphur, sulphur compounds, Epsom salts, etc., are frequently advertised as highly essential for birds. They have never been demonstrated to have any good effect. If birds are sick or out of condition, they need specific remedies; general tonics are of no value. Charcoal should also be mentioned in this connection. It is most generally recommended and used as a supplement to poultry rations. Much investigational work has been carried out in order to demonstrate the benefit of charcoal-feeding with no success. . . . Charcoal-feeding for poultry should be given up as an unnecessary expense.

Baby Chicks need High Protein Ration.—" Theoretical considerations strongly suggest the advisability of feeding more protein to baby chicks than to laying birds. Bunge (1905) has pointed out the close relationship between the rate of growth of different animals and the protein content of the mother's milk. This relationship is apparent from the following figures:—

Table No. 21.

Animal.	Days required for doubling Initial Weight.	Per Cent. Protein in Mother's Milk.	Nutritive Ratio of Mother's Milk.
Cow	47	3.5	1:3.8
Goat	22	3.7	1:3.6
Sheep	15	4.9	1:3.4
Hog	14	6.1	1:3.0
Rabbit	6	15.5	1:1.5

" It is quite evident that the rate of growth during early life is directly proportional to the per cent. of protein in the natural food, and consequently to narrowness of the nutritive ratio.

Protein Requirement decreases with Age.—" By determining the protein retention at different ages Bunge was also able to demonstrate that the protein requirements decreased as the rate of growth progressively slowed down. At the same time carbohydrate requirements increased in direct proportion to the increasing size of the animal.

Use Natural Food as Guide.—" Absorbed egg-yolk, which furnishes chicks with their first nutriment after hatching, has a protein content of about 44 per cent. and a nutritive ratio of 1:2.5. Mitchell, Card, and Hamilton (1926) have recently shown that Plymouth Rock chicks double their initial weight in fourteen to fifteen days, which is about the time required by a pig.

Consider Rate of Growth of Animals.—" When one considers the fact that the pig at birth is many times larger than the chick at hatching, and so requires a larger proportion of energy nutriments (carbohydrates or fat) than chicks, the implication is very strong that a chick ration should be much narrower than popularly supposed, narrower to begin with, in fact, than at any other time of life. It is also implied that the ration should be gradually widened as chicks grow and the rate of growth progressively slows down.

" This may be accomplished by feeding mash only for the first ten days and then introducing small and progressively increasing proportions of grain."—*Dr. Walter F. Holst.*

Abundance of Lime required.—" The need of laying hens for an abundant supply of lime for formation of egg-shell has long been recognized. Oyster-shell, or some other source of lime, is supplied to laying birds by all intelligent poultry-keepers.

Effect of Lime Deficiency.—" It is interesting in this connection to note that laying of shell-less eggs is due to some other cause than lime deficiency. The shell is absolutely essential for the development of the chick, because it supplies lime for bone formation. Though the supply in the food is inadequate, so long as the hen continues to lay she will, if necessary, deplete her own bones of lime to provide for the shell; though, in deficiency of lime, the supply may be conserved by the shell being formed thinner than usual.

Lime influences Egg Production.—" But the bones are not an inexhaustible reservoir, and ultimately the rate of egg production must slow down to the level at which the food can supply the necessary material. When there is insufficient lime in the food, therefore, egg production is less than when an ample supply is present. This is well shown by experiments in 1919 at Kentucky Experiment Station, U.S.A. Hens were fed in different groups with no access to the ground. The diet consisted of corn-meal, bran, middlings, meat, and charcoal as mash, and for grain, corn, wheat, and oats. Two groups were given each oyster-shell or limestone. The egg production in these two groups was, on the average, 69.4 per cent. greater than in the groups receiving no extra mineral matter.

Abundance of Minerals required for Egg Production.—" Though lime is the mineral most likely to be deficient in poultry-foods, phosphorus, chlorine, and, on certain rations, other minerals may be lacking in sufficient amounts, and the rate of growth, egg-laying, and hatchability of eggs thereby affected. At the Ohio Experiment Station some recent tests showed that even when oyster-shell, grit, and green food in the form of sprouted oats were supplied in unlimited amounts, the addition of a mineral mixture consisting of three parts bone phosphate to one of common salt and one of chalk increased the value of the ration for growth and egg production by more than 40 per cent.

Iodine improves Shell-texture.—" Reference has been made to the value of iodine for the prevention of certain conditions of malnutrition in pigs and sheep. It has also an influence on poultry. The results of experiments at Wisconsin seem to indicate that the addition of iodine to the food helps to prevent the laying of soft-shelled eggs. It is very probable that iodine has some controlling influence on the metabolism of lime salts in the body. Oyster-shell contains some iodine. This may account for its superiority over lime as a source of mineral supply for poultry.

" It is obvious that attention to the mineral content of the food of poultry would be repaid by increased profits to the poultry-keeper."—*Dr. J. B. Orr.*

MEAT-MEAL *VS.* FISH-MEAL FOR EGG PRODUCTION.

Central Experimental Farm proves Fish-meal better than Beef-scrap.—" In this experiment two different types and qualities of fish-meal were contrasted, one with the other, and with the control pen, receiving meat-meal. The rations fed to each pen were similar, except that a like amount of each fish-meal was substituted for the 15.8 per cent. of meat-meal of the basal mash. The three mashes thus contained 15.8 per cent. of ordinary fish-meal (57 per cent. protein), 15.8 per cent. of Fasterfat fish-meal (70 per cent. protein), and 15.8 per cent. meat-scrap (60 per cent. protein) respectively."

The table following shows details of the experiment:—

TABLE NO. 31.—DETAIL, MEAT-MEAL VS. FISH-MEAL FOR EGG PRODUCTION.

Pen and Special Feed.	Total Mortality.	Weight Gain or Loss.	Scratch-grain.	Value.	Mash.	Value.	Green Feed.	Value.	Grit.	Value.	Shell.	Value.	Total Value Feed.	Eggs laid.	Value.	Feed Cost per Dozen.	Profit over Cost of Feed.
		Lb.	Lb.	Cts.	Lb.	Cts.	Lb.	Cts.	Lb.	Cts.	Lb.	Cts.	Cts.		Cts.	Cts.	Cts.
Fish-meal (57 per cent. protein)	4	—0.1	26.37	63.27	23.39	57.00	7.10	9.43	0.88	0.77	1.67	1.55	132.02	93.1	444.81	17.0	312.79
Fasterfat fish-meal (70 per cent. protein)	3	—0.1	25.04	59.89	18.81	66.78	6.59	8.68	0.53	0.45	1.70	1.57	137.37	84.4	405.15	19.5	267.78
Control	5	+0.1	25.66	61.53	27.36	73.87	6.86	9.31	1.47	1.28	1.85	1.72	147.71	79.4	362.60	22.3	214.89

NOTES.—Feed costs were greater for the control pen as was also feed cost per dozen eggs produced. Production was considerably the highest on ordinary fish-meal as was profit over cost of feed. Apparently no advantage was gained in this experiment by feeding the more expensive fish-meal of high protein content. Both fish-meals gave superior results to the pen on meat-meal.

(Taken from Annual Report of Poultry Division, Central Experimental Farm, Ottawa, 1928; F. C. Elford, Poultry Husbandman.)

FEEDING LAYING PULLETS.

(At Dominion Experimental Farm, Agassiz, B.C.)

A series of feeding experiments was conducted from November 8th, 1927, to August 31st, 1928. Eight pens were included, consisting of 120 birds in all. The number of birds in an experiment varied from ten to thirty and final results were worked out on the basis of one bird.

The following outline describes the various experiments and the rations used in each:—

Simple Laying Rations compared.—(1.) Project P. 81—Relative value of different mashes. This pen was fed a mash composed by weight of 75 parts crushed wheat and 25 parts crushed oats in contrast to the mash (standard) described hereafter. The scratch-grain (standard), which consisted by weight of equal parts wheat, oats, and cracked corn, was the same in all pens. Skim-milk, green feed, and oyster-shell were also available and were on hand in other pens, except where mentioned to the contrary.

Prices per 100 lb.: Grain, $2.25; mash, $2.28; skim-milk, 25 cents; green feed, 25 cents; shell, $1.60.

(2.) Project P. 82—Beef-scrap *versus* skim-milk. The mash fed consisted by weight of 100 parts bran, 100 shorts, 100 corn-meal, 75 crushed oats, 25 alfalfa-meal, 60 beef-scrap, 10 bone-meal, 10 charcoal, 5 oil-cake meal; scratch-grain (standard), green feed, and shell were available, but no skim-milk was fed.

Prices per 100 lb.: Grain, $2.25; mash, $2.40; green feed, 25 cents; shell, $1.60.

Fish-meal proven better than Skim-milk.—(3.) Project P. 82—Skim-milk *versus* beef-scrap. This experiment was conducted similarly to the previous one, except that skim-milk but no beef-scrap was fed.

Prices per 100 lb.: Grain, $2.25; mash, $2.18; skim-milk, 25 cents; green feed, 25 cents; shell, $1.60.

(4.) Project P. 87—Fish-meal *versus* beef-scrap. The birds in this pen were fed similarly to those in Experiment No. 2, apart from the fact that they received fish-meal instead of beef-scrap, the proportion of each—namely, 12 per cent.—being the same in each case.

Prices per 100 lb.: Grain, $2.25; mash, $2.36; green feed, 25 cents; shell, $1.60.

Fish-meal proven better than Beef-scrap.—(5.) Project P. 87—Fish-meal plus beef-scrap *versus* beef-scrap. This group was handled similarly to the previous one, except that equal parts fish-meal and beef-scrap were fed, 6 per cent. in each case, the total combination of these being the same as either the beef-scrap or fish-meal in Projects 82 and 87—namely, 12 per cent.

Prices per 100 lb.: Grain, $2.25; mash, $2.38; green feed, 25 cents; shell, $1.60.

(6.) Project P. 107—Methods of feeding layers. Grain in litter *versus* grain in hopper.

The grain mixture (standard) consisted of equal parts wheat, oats, and cracked corn. The mash (standard) was composed by weight of 100 parts bran, 100 shorts, 100 corn-meal, 75 crushed oats, 25 alfalfa-meal, 75 beef-scrap, 10 bone-meal, 10 charcoal, 5 oil-cake meal. Skim-milk, green feed, and oyster-shell were also available.

Prices per 100 lb.: Grain, $2.25; mash, $2.45; skim-milk, 25 cents; green feed, 25 cents; shell, $1.60.

(7.) Project P. 107—Control pen. This pen was fed exactly the same as the previous one, prices of feed being also the same.

(8.) Project P. 107A—Grain in hopper *versus* grain in litter. The only difference between the handling of the birds in this group and in the two immediately preceding was that the grain was fed in a self-feeding hopper instead of in the litter. Prices of feed were the same.

EXPERIMENTS IN FEEDING—RESULTS FROM LAYING PERIOD, NOVEMBER 1ST, 1927, TO AUGUST 31ST, 1928.

Group.	Eggs per Bird.	Value of Eggs per Bird.	Cost of Feed per Bird.	Profit over Cost of Feed per Bird.
1. Basal ration using fish-meal instead of beef-scrap	196	$4.90	$2.20	$2.70
2. Basal ration without beef-scrap plus skim-milk	197	4.92	2.26	2.66
3. Basal ration with 6 per cent. each of fish-meal and beef-scrap	189	4.72	2.16	2.56
3. P. 107A—Grain in hopper	189	4.72	2.16	2.56
4. P. 107—Grain in litter	183	4.57	2.09	2.48
P. 107—Grain in litter	183	4.57	2.21	2.36
5. Basal ration—Control pen (beef-scrap)	187	4.67	2.26	2.41
6. P. 81—Mash: 75 parts crushed wheat and 25 parts crushed oats by weight	175	4.37	2.17	2.20

The following summary gives an indication of the foregoing experiments in order of profit over cost of feed per bird. This refers only to the results of one year.

The group which received fish-meal instead of beef-scrap and no skim-milk gave best results. This would suggest that a good brand of fish-meal has its place in a poultry-mash.

Skim-milk with no beef-scrap came a close second in order of profit, this indicating the value of skim-milk in a poultry ration.

The fish-meal plus beef-scrap lot, but no skim-milk and those receiving grain in hopper, tied for third place. The results from the former of these suggest that a combination of fish-meal and beef-scrap may be preferable, under certain conditions, to the use of beef-scrap alone. The results from the group receiving grain in hopper are unexpected in that they are better than those from birds fed grain in litter.

Beef-scrap with no skim-milk gave results lower than any of the former. This indicates that when skim-milk is available or a desirable brand of fish-meal, good results are possible, even without beef-scrap.

The group receiving a mash composed by weight of 75 parts crushed wheat and 25 parts crushed oats gave the poorest results, due to the fact possibly that the mash was incomplete in its composition.—*Taken from Annual Report, 1928, of Experimental Farm, Agassiz, B.C.; W. H. Hicks, B.S.A., Superintendent.*

PART IV.—SHEEP.

THE FEEDING OF SHEEP.

Breeding Ewes need Protein.—" Sheep are kept under such a variety of conditions that it is impossible to make more than a general suggestion about their feeding. The critical periods in the life of the sheep are, as with other stock, during gestation and during early growth. Difficulty is often experienced owing to improper and inadequate feeding of lambs and in-lamb ewes. Proteins and minerals are the principal requirements of grazing sheep during these periods and a little concentrated food should always be given. The inclusion of about 5 per cent. of fish-meal in these concentrates will be a great advantage. Mr. Tod suggests the following as a ' first-class mixture for lambs.' "—*Corrie.*

Ration used in England.

	Per Cent.
Crushed oats	50
Linseed-cake	15
Crushed beans	15
Dried grains	10
Middlings	5
Fish-meal	*5*

He also advises this mixture for preparing rams for show or sale. Fish-meal is an excellent supplementary food for sheep on roots.

Feed Fish-meal to Sheep.—It is also recommended that fish-meal be fed to sheep at the rate of $^1/_{10}$ to $^1/_5$ lb. per 100 lb. of live weight.

Fish-meal makes Good Bones.—" With regard to animal products, milk residues, if they contain the ash of milk, are of special value, because all the essential minerals are present in it in the proportions required for growth. In the same way, *fish-meal, being made from bones and flesh,* contains the mineral matter to form these; it contains such large quantities of calcium, phosphorus, and the other minerals that the addition of even small quantities of it to a ration ensures an ample supply of all the *essential minerals.*"—*J. B. Orr and A. Crichton, Rowett Institute, Aberdeen.*

IODINE FOR SHEEP.

B.C. Range Sheep need Iodine daily.—" Iodine administered to the pregnant ewe will definitely control goitre in lambs, where such abnormality exists, notably in known iodine-deficient areas. Apparently it has a marked but not so thoroughly proven effect on falling or loose wool. Apparently, too, it has a most beneficial effect where for no distinct reason weak lambs, overgrown, flabby lambs, or premature births are common.

Method of Administration.—" In the form of an iodized salt. Where such is used the year round, it is quite likely that a commercial iodized salt will be effective. Where an iodized salt is used during the period of pregnancy only, results secured on certain of the Experimental Farms would make it appear doubtful as to whether 0.02 per cent. potassium iodide (as in commercial salt) is sufficient. On the Experimental Farm System where experimental work has been carried on in this connection for a number of years, the following practice is followed: Dry 100 lb. fine commercial salt; spread it thinly and evenly on a canvas or tarpaulin; dilute from 2 to 4 oz. of potassium iodide crystals in a pint or so of water; sprinkle or spray this solution evenly over the layer of dry salt, which will take up the liquid; mix thoroughly; keep dry and place before the ewes during the winter. It is not definitely known whether these quantities (2 to 4 oz.) are optimum. It has been shown that 4 oz. is effective under a variety of conditions, although likely in excess for general use. It has been shown in one instance that 1 oz. per 100 lb. is not fully effective in controlling goitre. On the other hand, 1 lb. of potassium iodide to 100 lb. of salt has been used with

sheep without toxic effect. This was done for comparative experimental evidence, the iodide was greatly in excess of requirement, the mixture therefore very expensive, and its use exposed the ewes to unnecessary danger. Possibly the happy medium of 3 oz. per 100 lb. of salt would be generally effective, although likely in excess of any actual requirement. Anyway, it is safe, reliable, and effective. It will be seen, however, that there is a considerable range between the iodine content of commercial iodized salt (0.02 per cent.) and the home mixture recommended (from 0.125 to 0.25 per cent.).

"It is true that Hanzlik, Talbot, and Gibson, in the Archives of Internal Medicine (Vol. 42, No. 4, Oct., 1928) state that 'the objections which have been raised against the prolonged administration of iodine in small doses are conspicuously unsupported by trustworthy evidence.' The results of their own experiments on rats given the relatively heavy dose of 1 milligram of iodide per head per day, for periods varying between one-seventh and seven-twelfths of the span of life, indicated that such treatment was not merely not detrimental, but on the contrary was beneficial along various lines. The writer is informed, also, that at the Rowett Research Institute in Aberdeen, in recent experiments designed to gauge the tolerance of various animals for iodine, increasing doses were fed for several months (three to seven) until pigs were getting the enormous quantity of 5 grams, calves 4, sheep 0.3, and poultry 0.3 grams of iodide per head per day without showing any toxic effects. Nevertheless, in some cases there may be danger in materially increasing the quantities here suggested for regular or prolonged use, and for purposes of economy, if no other, the potassium iodide should be kept down as close to the effective point as possible."—*"The Significance of Iodine in the Feeding of Live Stock" (Rothwell).*

PART V.—THE HORSE.

Horses need Minerals.—"The mineral requirements of the horse have received even less attention than those of the cow. But there is a certain amount of well-established information that shows the importance of mineral matter in the diet of the horse. There seems to be a consensus of opinion that certain districts are specially suitable for rearing horses of good bone, and that in those districts the soil, and consequently the pasture and fodders grown on the soil, are rich in lime and phosphorus, the two minerals needed in largest amounts for bone formation.

Effect of feeding Bran to Horses.—"There is definite evidence to show that diseases, chiefly affecting the bones, are produced by foodstuffs with excess or deficiency of certain mineral elements. 'Bran rickets' or 'miller's bone-disease' is caused by feeding excessive amounts of bran which contains an enormous excess of phosphorus and very little lime. Ingle has shown that in South Africa a somewhat similar disease occurs in horses in certain districts where the pasture and fodder crops have a great excess of phosphorus and a deficiency of lime. On the other hand, deficiency of phosphorus in the feeding-stuffs, as occurs in Bihar in India and in certain other regions, leads to a disease characterized by loss of co-ordination and of muscular power in the hind limbs and to porosity of the bones. This disease is probably the same as that referred to above as being produced experimentally in pigs on a phosphorus-deficient diet.

Effect of certain Feeds on Horses' Legs.—"In street-horses, affections of the bones of the legs are much more common than in farm-horses. It has been perhaps too hastily assumed that the hard nature of the road and strenuous work are alone responsible for the lesions in the bones in the former case. From the known requirements of the animal, one would expect that the food should contain lime and phosphoric acid in about equal amounts. But the street-horse is usually fed on foodstuffs with a large excess of the latter. Oats, the best balanced of all the grains, has about six times as much phosphoric acid as lime. Bran has over thirty times as much. Further, the street-horse is often kept on the same ration for long periods. The continual excess of certain minerals and deficiency of others is bound eventually to affect the texture and the composition of the bones, rendering them softer and more liable to injury.

Why Horses improve on Pasture.—"The farm-horse, on the other hand, receives usually a greater variety of feeding-stuffs. For the great part of the year, also, it gets a certain amount of grazing, and the minerals of the pasture supply what is liable to be deficient in stall-feeding. It not infrequently happens that a street-horse in bad condition, when put upon a farm, shows after a few months a marked improvement in its limbs. The improvement is probably due as much to the change in the diet as to the change in other conditions.

Horses eat Minerals readily.—"The quality of the bone affects to a great extent the value of the horse. It has been shown by carefully conducted experiments that in the case of the pig the hardness and density of the bone can be markedly increased by modifying the mineral content of the food by the addition of inorganic salts. There is no difficulty in getting the horse to eat mineral salts incorporated with its food."—*Dr. J. B. Orr.*

FISH-MEAL FOR HORSES.

Just as one might expect, the feeding of fish-meal to horses, especially brood mares, has been as successful as the feeding of this product to other classes of live stock.

Balance the Horse's Ration.—It is equally as essential to balance the ration of a horse as any other animal, but little attempt is ever made in this direction. The usual ration of timothy-hay, oats—and occasionally a bran-mash—is far from being a balanced ration; especially with hay and oats which have been grown on soils of known, or suspected, deficiency such as are to be found in many parts of British Columbia.

Horses like Fish-meal.—It is not quite so easy to get horses as pigs to eat fish-meal, but with a little ingenuity on the part of the feeder, horses will soon take to a ration containing fish-meal if it is added in small quantities at the outset. The amount may be gradually increased from an ounce or so per day up to 2 lb. per day for a brood mare. It is altogether likely that the frequent losses of foals from the common ailments can be largely reduced by the use of fish-meal in the ration of the mare.

Protein Requirement of the Horse.—Very little is known about the protein requirement of the horse, but using other farm animals as a basis, a horse of 1,200 lb. live weight should have at least 1 lb. crude protein daily even when not working. Heavier horses would require more in proportion to weight and brood mares should have about 25 per cent. more. The tables in the Dairy Cattle section of this bulletin could be used as a guide in figuring out economical rations for the horse.

PART VI.—FISH-MEAL FOR FOXES AND OTHER FUR-BEARING ANIMALS.

Replace Fresh Fish with Fish-meal.—At the Experimental Fox Ranch, Summerside, P.E.I., the feeding of fish to foxes is an established practice. This results in considerable economy in feeding costs, but the greatest advantage probably lies in the improvement in health which is likely to result. The fox is a carnivorous animal by nature and its natural food is small animals such as rabbits, etc. It may be significant that foxes seem to have a greater liking for the glandular organs than for muscle-tissue, for it is well known that they devour parts of the intestines of their prey before eating very much of the other parts of the body.

Fish-meal Ideal for Foxes.—Fish-meal made from small fish such as the pilchard contains all of the fish with the exception of most of the oil and water. It therefore contains all of the glandular organs as well as the bones, hence it is logically an ideal feed for foxes kept in confinement. It should, however, be fed with discretion, as 1 lb. is equal to about 5 lb. of fresh fish or about 4 lb. of fresh meat.

Fish-meal keeps indefinitely.—Fish-meal has the added advantage that it may be kept indefinitely without deterioration, as it has been completely sterilized in the process of manufacture and putrefactive organisms which might be present in fresh products have been destroyed.

Protein Requrement of Young Animals.—All of the advantages of feeding fish-meal to domestic live stock would apply to fur-bearing animals, and you are therefore invited to consult other sections of this bulletin which deal with the protein and mineral requirements of young growing animals of other species.

FISH-MEAL—SUPPLY, DEMAND, AND PRICE.

Supply of Fish-meal is Large and Price is Low.—We are sometimes asked what effect on price there may be as a result of increased domestic demand for this commodity. The supply has always exceeded the demand, as may be seen by reference to Table No. 22 below, and this condition is likely to continue indefinitely, for not all the sources of supply have been exploited as yet. Another factor affecting price is the demand in other countries. We export nearly two-thirds of our annual production, and it is really the export price which influences domestic prices rather than domestic demand. When the demand for fish-meal in Western Canada approaches British Columbia production, it is safe to say that either more reduction plants will be established or those in existence will increase their present capacity. The following extract from the 1928 Report of the Commissioner of Fisheries (Provincial) will be of interest: "The production of fish oil and meal in the Province in 1928 shows a large increase. The twenty-three fish-reduction plants on the west coast of Vancouver Island produced 4,035,879 gallons of oil and 15,280 tons of meal. . . . Four new plants were in operation. The fish meal and oil products of the Province are exported, England, Germany, and the United States being the largest importers."

TABLE NO. 22.—PRODUCTION OF FISH OIL AND MEAL, 1924–1929.

Year.	From Pilchards.		From Herring.		From Whales.			From other Sources.	
	Meal and Fertilizer.	Oil.	Meal.	Oil.	Whale-bone & Meal.	Ferti-lizer.	Oil.	Meal.	Oil.
	Tons.	Gals.	Tons.	Gals.	Tons.	Tons.	Gals.	Tons.	Gals.
1924	.....	.....	.....	.....	292	926	645,657	1,709	241,376
1925	2,083	495,653	.....	.....	347	835	556,939	2,468	354,853
1926	8,481	1,898,721	310	13,700	340	666	468,206	1,752	217,150
1927	12,145	2,610,120	2,218	173,343	345	651	437,967	1,948	250,811
1928	14,502	3,997,656	788	61,245	376	754	571,914	3,205	387,276
1929	15,630	2,633,378	.....	.....	503	780	712,597	3,772	328,827

Compare Cost of Fish-meal with other Concentrates.—The cost per ton of a feeding-stuff is a most deceptive basis for figuring its worth. If we are buying a feed to use as a protein concentrate we must give first thought to the cost per pound of digestible protein rather than to the cost per ton. Supposing we are buying bran for its protein content alone, then, at $36 per ton, 1 lb. of protein would cost 15 cents, whereas 1 lb. of protein in the form of linseed-meal at $66 per ton would cost only 11 cents. On the other hand, fish-meal costing $70 per ton would give us protein for just about half that, or 6 cents per pound. On the basis of cost per ton, fish-meal would therefore be worth twice as much as linseed-oil cake, for, as Hicks proved at Agassiz, 1 lb. of fish-meal is equal in value to 2 lb. of linseed-oil-cake meal. Fish-meal, however, rarely costs as much as $10 or $15 more per ton than linseed-meal; and it has the further advantage that it contains about 12 per cent. bone phosphate at no added cost whatever. It has been pointed out elsewhere in this bulletin that animal proteins (such as fish-meal) have a value at least 10 per cent. greater than cereal or vegetable protein concentrates of similar protein content, due to the easier digestibility of the animal proteins.

Save Money by using Fish-meal.—Taking British Columbia as a whole, the price of fish-meal averages about $80 per ton, whereas its value as compared with linseed-oil-cake meal would be in the neighbourhood of $135 per ton. The saving by using fish-meal instead of other protein concentrates such as linseed-oil-cake meal is therefore well worth while considering, on the basis of price alone.

Fish-meal ensures Economy.—The economical production of milk, meat, or eggs in British Columbia depends for its success on the feeding of home-grown forage and cereals—and the use of a home-produced protein concentrate, fish-meal.

GROWING COMMERCIAL IMPORTANCE OF FISH-MEAL.

Fish-meal produced in other Countries.—" Production and exports of other countries: Norway produces over 50,000 tons yearly, judging from the amount of Norwegian fish-meal imported into Germany. The larger portion of the Norwegian production is herring-meal, so-called ' white ' fish-meal being produced in decidedly smaller quantities.

Fish-meal not now used for Fertilizer.—" The United Kingdom produces some 40,000 tons of fish-meal and scrap, mostly meal. Prior to the war some 30,000 tons were exported to Germany for fertilizer. At present the fish-meal thus produced is mostly for domestic consumption and for feed purposes.

" India's production of fish-scrap or guano is over 35,000 tons, as this amount has been exported during a twelve-month period. Some 600 factories are in operation along the Malabar and the South Kanara Coast, the outturn of which is over 20,000 tons.

Greatest Consumption in Germany.—" Chief consuming countries: The chief consuming countries are Germany, the United States, the United Kingdom, the Netherlands, and Japan. Germany alone will have consumed this year (1928) approximately 100,000 tons, 90 per cent. of which has had to be imported. This amount is almost equal to the total output of fish-meal in both the United States and Norway. The imports of fish-meal into Germany increased from 6,302 tons in 1923 to 26,993 in 1924, to 45,700 tons in 1925, and to 82,000 tons in 1926. This indicates a phenomenal growth in the use of the product."

REFERENCES.

Most of the quotations in this bulletin are taken from papers other than the originals, hence it has not been possible to give full reference to the sources of much of this valuable information.

The editor wishes to express his great indebtedness to his colleagues and associates who by their active collaboration and helpful criticism have made the bulletin possible.

R. DeL.

August, 1930.

SUPPLEMENT A.

RECENT ADVANCES IN ANIMAL NUTRITION.

W. Godden, B.Sc., A.R.C.S., F.I.C., Head of Chemical Department,
Rowett Research Institute, Aberdeen.

(Reprinted from "Agricultural Progress," Vol. V., 1928.)

The modern trend of animal husbandry is all in the direction of intensive production. The stock-breeder and feeder of the present day desires to obtain young animals capable of a very rapid rate of growth, dairy cows which will give high yields of milk, and hens with a high egg production. Thus we now have pigs reaching 2 cwt. in weight in six months, baby beef animals weighing 7 to 8 cwt. in twelve months, dairy cows giving 1,000 to 2,000 gallons of milk and even more in a lactation, and hens laying 200 to 300 eggs in a year. As a result there is a risk that some of the old rules governing the rationing of stock, whilst adequate to slower productive conditions, may not hold good under present circumstances. Whilst they may suffice for balancing up the organic or energy-yielding portion of the ration, they probably fall short in respect of those other constituents, such as mineral matter and accessory food factors, which, while present in relatively small amount, are none the less essential for normal growth.

It can be shown by a comparison of the growth-rate and the composition of the milk of the species (Table 1) that the faster the rate of growth, the greater the absolute amount of mineral matter required in a given time and the higher the proportion of mineral matter to energy units needed in the food.

Table 1.

Species.	Number of Days in which Weight of New-born Animal is doubled.	Milk of Species contains:			
		Protein.	CaO.	P_2O_5.	Ash.
		Per Cent.	Per Cent.	Per Cent.	Per Cent.
Man	180	1.6	0.049	0.056	0.25
Cow	47	3.5	0.161	0.189	0.72
Pig	14	6.7	0.395	0.357	1.03

Thus, then, with the accelerated live-weight increase of the modern animal, there is an increased risk of a deficiency of mineral constituents with respect to energy value and also of a lack of balance between the different mineral constituents.

The evolution of faster-growing types of animals has led to an increasing use of concentrates in feeding. Many of these artificially prepared concentrates are by-products in manufacturing processes, and as a result of such treatment are deficient in some of those mineral and other constituents essential to growth. Consequently, so-called deficiency diseases have become more and more prevalent in recent years, and it is in the study of such diseases and their relationship to the feeding of the animal that most progress has been made in animal nutrition.

The two main groups of food constituents which have received the most attention in this connection are (*a*) vitamins and (*b*) mineral constituents. Along with these, however, there must be borne in mind the influence of what may be called external factors, such as methods of feeding and the effect of sunlight, either natural or artificial (such as ultra-violet irradiation). It is the purpose of the writer, in preparing this article, to deal mainly with the above two groups of constituents and to endeavour to summarize our present state of knowledge of them and indicate how far this knowledge finds practical application in the

feeding of farm animals. Other items of research bearing on animal nutrition will also find reference.

Vitamins.—The literature on vitamin research is so vast and varied in character, papers following one another in such quick succession, that it is difficult to keep pace with the subject or to evaluate the practical importance of these accessory factors in agriculture. Our knowledge as to the number of vitamins is somewhat in a state of flux, but it would appear that, at present, five definite vitamins, denoted by the letters A, B, C, D, and E, are recognized. The occurrence of these different factors in nature and their connection with deficiency diseases may be briefly outlined as under.

Much of the work in this country in support of the vitamin hypothesis in its relation to agriculture has been done by Golding, Drummond, and Zilva, and their co-workers. In experiments with dairy cows they have found a considerable variation in the Vitamin A content of milk, with different conditions of feeding. Under winter conditions of stall-feeding the Vitamin A content of the butter was only about one-tenth of that found when the cows were on grass. Cod-liver oil, when fed to the cows in the winter to supply Vitamin A, brought the butter up to its summer value with respect to this vitamin. In a series of experiments with pigs they found it was possible in some cases to induce rickets, with the manifestation of osteoid tissue, by depriving them of the anti-rachitic vitamin, in the absence of direct sunshine.

In considering the importance of these accessory factors in farm practice, it should be borne in mind that most of the experimental work has been carried out with small animals (e.g., rats, guinea-pigs), and it does not always follow that results obtained in such a manner will be applicable to farm stock. Feeding experiments conducted at the Rowett Institute indicate that, on a properly balanced ration, with the animals kept under normal conditions in respect of sunlight and exercise, there is but little risk of disease due to deficiency of vitamins. Thus, then, provided the stock-feeder gives his stock free run, so that they may get the benefit of fresh air and sunlight, and provided he supplies them with a mixed diet in which is included a reasonable proportion of fresh green food, it is doubtful if he need worry himself about vitamins. Where attention may need to be given to these factors is in the case of stall-fed animals, with little or no outdoor exercise, young animals; e.g., calves reared on artificial foods in place of their mother's milk, or poultry kept on the intensive system. In such cases failure to grow, general unthriftiness, or symptoms of rickets may be indicative of absence of one or more of the above vitamins and attention should be given to the ration to ensure an adequate supply.

Mineral Constituents.—The requirements of animals for various inorganic salts received but scanty attention until comparatively recent times. It was known that all commonly-used foodstuffs contained certain amounts of "ash" or total mineral matter, and it was assumed that any animal fed on an ordinary mixed ration would receive sufficient of the various essential minerals and that attention need only be paid to protein and energy requirements. It is now coming to be recognized that many of the problems of animal nutrition, bearing upon both the economical use of feeding-stuffs and the incidence of disease, are intimately bound up with the supply of mineral matter in the food.

Living matter contains, as inorganic constituents, the metallic elements—calcium, sodium, potassium, magnesium, and iron—and non-metallic elements, phosphorus, sulphur, chlorine, and iodine, and probably traces of other elements such as manganese and fluorine. These inorganic constituents are as essential to animal life as the organic constituents (protein, fats, carbohydrates). Directly or indirectly they stimulate or control all the vital processes, and their complete absence from a diet has been shown to cause a more rapid and painful death than complete starvation.

Functions of the Mineral Constituents.—The fundamental importance of these mineral constituents to the animal may best be emphasized by a consideration of the functions which they perform in the body.

(1.) In the mature animal they are necessary for the maintenance of a proper physiological balance between the mineral constituents in the body-fluids. Excess or deficiency of one of the mineral elements in the blood may affect the vital processes. For example, a deficiency of potassium will prevent the heart-muscle from relaxing properly, while an excess makes it relax so completely that it stops beating. Thus the actual concentration of potassium must be correct, and, further, it must be in proper ratio to the other inorganic elements. Then the mineral constituents play an important part in maintaining the blood practically neutral in reaction. A slight departure from this will produce pathological symptoms; e.g., increased acidity is followed by disturbance of the respiratory mechanism and of the nervous system.

In the maintenance of this physiological balance in the body-fluids the animal organism is a remarkably effective regulating mechanism. Thus, through the kidneys, it will eliminate minerals which are in excess; and, by reabsorption through the walls of the intestine, it will conserve those liable to be deficient. Further, it will draw upon its own storehouse —e.g., the bones—to make good deficiencies in the blood. Whilst it is true that this mechanism of internal regulation may enable an animal to tide over a period of ill-balanced feeding, there comes a time when the mechanism breaks down, with consequent deleterious results to the animal's health.

(2.) The mineral constituents are necessary for the processes of digestion. Experiments with dogs have shown that, if the diet be freed from minerals, the animal becomes unable to digest it and will after a time vomit the food unchanged. The digestive processes are affected by the acidity or alkalinity of the contents of the gut. Thus in the stomach the reaction must be acid to enable the pepsin to act properly, whilst in the small intestine it must be alkaline for the trypsin to act. This regulation is brought about by the mineral constituents. Subsequent to digestion the absorption of the products is controlled by the concentration of salts in the intestinal contents, and this concentration will also affect the passage of digested and undigested material along the intestine. Work in progress at this Institute by Magee shows that the inorganic elements have very marked and differing effects on the rhythmical contractions of the isolated mammalian intestine.

In addition to the performance of the above functions of maintenance, the growing animal requires mineral ingredients for constructive material, for the formation of new tissue, and the building-up of the skeletal framework. Milking animals require these ingredients to make good the minerals secreted in the milk, and laying hens for the material for their eggs.

Recent research dealing with the mineral nutrition of farm animals has concerned itself with (*a*) the mineral requirements of different species for individual constituents; (*b*) the correct balance between the different constituents; (*c*) the relationship between the inorganic and organic portion of the ration; (*d*) the effect of external factors such as sunlight and exercise on the mineral metabolism; (*e*) the study of various diseases resulting upon faulty mineral nutrition, and (*f*) the mineral composition of feeding-stuffs.

(a.) Mineral Requirements.—The two minerals required in largest amount for growth—namely, calcium and phosphorus—have been most studied; and it is now generally accepted that a growing pig requires to build into its body about 1 lb. of lime (CaO) and the same amount of phosphoric acid (P_2O_5), and a calf nearly double these amounts, for every 100 lb. of live-weight increase. But, as a rule, only about 50 per cent. of the lime and phosphoric acid in the ration can be assimilated and retained, hence the food should contain at least double the above quantities. Such exact information is not available with reference to the supplies of the other mineral elements required by growing animals, and at present the best guide is probably the composition of the milk of the species. (*See* table on page 14, mineral constituents of cow's milk.)

Attention has also been paid to the requirements of lactating animals for calcium and phosphorus. It has long been known that a heavy-milking cow will draw very considerably upon its own reserves of these two elements to supply the amounts given in its milk.

Numerous balance experiments have been conducted in an endeavour to find a means of converting these negative balances of calcium and phosphorus during lactation to positive balances or to keep the animal in equilibrium. Forbes (1912) was unable to obtain a positive calcium balance with cows during the first half of lactation, despite superabundant supplies of calcium, phosphorus, and other minerals. Hart and his co-workers (1922) succeeded in obtaining positive calcium balances by feeding alfalfa-hay. They were, however, in later experiments only able to reduce, but not make positive, the negative balances of milking cows by substituting alfalfa-hay for timothy-hay. Addition of bone-meal to the timothy-hay had the same effect. These latter results they attributed to faulty curing of the hay which caused a destruction of the vitamin assisting calcium assimilation. Gaessler and McCandlish obtained positive balances with fresh alfalfa, but negative when old alfalfa was used. Other workers record beneficial effects from feeding fresh green food. Hart, Steenbock, and Hoppert found that, with milking goats, the administration of cod-liver oil (5 to 10 c.c. per day) converted negative to positive calcium balances, but the oil was not well tolerated.

It has been suggested by Hunter and co-workers that the calcium in green food and carefully-won hay is in a more highly dispersed condition, hence better digested and assimilated, than in dry hay. In support of this view they quote experiments where positive results were obtained by feeding tricalcium phosphate precipitated on starch.

(b.) Balance between the Different Mineral Constituents.—It is now known that an alteration in the balance of two or more mineral constituents of a ration may affect the assimilation not only of these elements, but also of other constituents of the ration. Thus Henderson, working with pigs, found that, with a ration where the ratio of CaO to P_2O_5 was practically 1 : 1, there was adequate assimilation and retention of both elements; but where the ratio was only 1 : 2.5 the balances were very much lower and the animals responded to ultra-violet irradiation.

It has long been held that an excess of potassium in a ration depletes the organism of sodium, and vice versa; this hypothesis was dependent upon somewhat incomplete investigations carried out by Bunge more than fifty years ago. Recent work by the writer in conjunction with Richards and Husband has shown that, while this may be immediately true, the effect is only temporary and the animal speedily adjusts itself to the new conditions. The real effect is rather on the nitrogen, calcium, and phosphorus balances; a high ratio of K_2O : Na_2O tends to lower the assimilation of these constituents, whereas when the sodium is in excess the assimilation is raised. This may be the explanation of the beneficent results of feeding sodium chloride to stock. In this connection it is interesting to note that Theiler, Green, and duToit have recently recorded experiments in which they find that, in the case of cattle, sodium requirements for growth are very low and that a high ratio of potassium to sodium is not productive of specific disease.

(c.) Relationship of Inorganic to Organic Constituents of the Ration.—As has been mentioned in the introduction, a ration may be amply provided and balanced with respect to protein, fat, and carbohydrate, but deficient in minerals, and the animal may still fail to make normal growth. Supplementing such a ration so as to make good its mineral deficiencies will result in markedly increased growth and much more economical utilization of the foodstuffs. That this is the case has been proved by numerous experiments and by many practical feeders to their monetary advantage.

The individual organic constituents may also have their effect on the utilization of the mineral constituents of a ration. Thus we have found that with pigs on a ration badly balanced with respect to calcium and phosphorus, the addition of cod-liver oil, linseed-oil, or olive-oil caused a rise in the calcium and phosphorus balances.

(d.) External Factors.—Reference has already been made to the effect of sunlight or artificial irradiation in improving calcium and phosphorus assimilation in pigs on a ration deficient in calcium. This result was confirmed by subsequent analyses of the bones, those of the irradiated pig showing a definitely higher percentage of calcium and phosphorus than

those of the non-irradiated pig. Henderson extended his experiments to lactating goats and found that irradiation reduced the loss of calcium from the animal and, in one experiment, converting a negative calcium balance into a positive one. It must be noted in this connection, however, that certain rather ill-defined cases have been reported where irradiation has had a detrimental effect on the health of the animal. · Whilst these latter cases are few, the positive results are sufficient to warrant the advocacy, if such is necessary, of giving animals free access to sunlight.

(e.) Deficiency Diseases.—It is not possible within the compass of this article to deal with all the cases of disease or malnutrition consequent upon mineral deficiencies in the ration of the animal. These diseases have been reported from all parts of the world, and it is hoped that, as one of the results of the recent Imperial Agricultural Research Conference, a concerted attack on this aspect of animal nutrition will be made throughout the Empire.

Disease may also arise from a deficiency of elements like iron and iodine, which, though only present in most foodstuffs and only required by the animal in small amounts, are none the less essential to the health of the animal.

Some of the earliest observations on iodine in relation to animal nutrition are those on the occurrence of goitre in sheep, accompanied by a heavy death-rate in lambs, in Michigan, where the trouble was eradicated by feeding salt deposits, rich in iodine, from the Great Lakes. Ennis Smith at Montana investigated the disease known as the hairless-pig malady and found that it was due to a deficiency of iodine in the ration of the mother, and that it was readily prevented by feeding potassium iodide (1.5 grains per day) to the sow during gestation. Both of these observations have since received ample confirmation both in Canada and the United States. (*See* quotations from Rothwell on Iodine-feeding in Cattle, Sheep, and Swine sections of this bulletin.)

More recent work has had reference to the effects of iodine-feeding on live-weight increase, viability of the young, yield and composition of the milk. Experiments with pigs at the Iowa station showed a 10-per-cent. increase in the average daily gain in weight and a decrease of 10 per cent. in the food required per pound of live-weight increase, when iodine as potassium iodide was fed at the rate of 4 to 40 mg. per day. Similar positive results were obtained in two experiments at this Institute, but further repetition showed no effect for the added iodine. Negative results are recorded from the Dominion Experimental Farm, Canada. Continental workers have found that feeding iodine to breeding sows, during the last three weeks of gestation and the suckling period, has a marked beneficial effect on the viability of the young and the rate of their growth. Other investigators working with sheep found that a dose of 40 mg. of potassium iodide per day increased the rate of growth of lambs by 20 to 30 per cent., but that higher doses had irregular and sometimes detrimental effects.

The administration of potassium iodide (up to 180 mg. per day) to cows has been found by Continental workers to increase the yield of milk or to delay the fall towards the end of lactation and at the same time to increase the iodine content of the milk; on the other hand, it slightly reduced the percentage of fat in the milk. This effect on the iodine content of the milk has been confirmed at this Institute; but experiments with goats did not show the fall in percentage of fat, possibly owing to the use of much smaller doses of iodine.

Finally, there are indications that iodine may be of use, either as a nutrient or a therapeutic agent, in the treatment of such diseases as joint-ill in foals and foot-and-mouth disease.

It may not be out of place to caution readers in using a material such as potassium iodide for nutritional purposes; the positive results have been recorded by the use of small doses; it is quite probable that, if the optimum amount be materially exceeded, deleterious effects will occur. Whilst no definite evidence is available as to the optimum doses for different species of animals, it would appear that it is not usually desirable for the daily dose to exceed about four ten-millionths of the live-weight of the animal.

(f.) Mineral Content of Foodstuffs.—In the past, the mineral constituents of foodstuffs have been considered only from the point of view of residual manurial values, and most

tables giving the composition of foodstuffs state only the total ash or at the best certain of the ash constituents. Information is being accumulated and it is hoped shortly to publish a bulletin giving fairly full data as to the various mineral constituents of home-grown and purchased foodstuffs used in this country. In so far as concerns home-grown crops, it is known that their composition may be materially affected by various factors, and the crop which has, of recent years, received the most attention is grass.

PASTURE-GRASS.

A considerable volume of recent work has been carried out in this country on the composition of pasture-grass, both from the point of view of its general nutritive value and from that of its mineral content and factors affecting the same. Space will permit of but a brief reference to these researches.

At Aberdeen this work has turned mainly on the composition of hill pastures, and the results indicate wide differences between cultivated grass and that of poor hill pastures. Passing from cultivated pastures through good hill pastures to poor hill pastures, the results indicate a steady drop in both the nitrogen and the mineral-matter content of the dry matter of the herbage; the poor hill pastures show a general deficiency in mineral constituents. These uncultivated pastures show marked differences in the mineral content in different localities, and there is a rough correlation between mineral content and the occurrence of disease or symptoms of malnutrition in the sheep grazing thereon. Sheep, when having free choice of grazing, choose those pastures whose mineral content most closely approximates to that of good cultivated pastures.

The results of analyses of samples, taken at regular intervals throughout the growing season in fields continually grazed, show that there is a seasonal variation in the various mineral constituents. The nature of the curves showing this variation and the date of the maxima are affected by the method of grazing. These results are borne out by the work at Aberystwyth, where Fagan has found a similar seasonal variation. He has also studied the relative composition of leaf and stem; and finds that the former is richer than the latter in nitrogen, silica-free ash, and lime, though there is little difference in their phosphoric acid content. Thus the method of stocking which tends to keep the herbage short and leafy will give the feed of highest nutritive value.

Work by Woodman at Cambridge has thrown new light on the nutritive value of pasture and the relative value of hay and grazing. From two series of digestibility trials in successive seasons on grass grown on different types of soil, weekly cuts being made, it is shown that pasture-grass possesses a much higher nutritive value than has hitherto been suspected. It is concluded that, irrespective of botanical composition, or the presence of little or much wild white clover, a pasture will yield a herbage whose dry matter will be exceedingly rich in protein. Further, under a system of close grazing, the high content of protein will be maintained throughout the season.

In composition and digestibility, well-grazed pasture-grass compares favourably with concentrates like linseed-cake. Further, in a comparison of pasture and hay it was found that, although the hay-plots gave a higher yield of dry matter per acre, the pasture-plots gave a slightly higher amount of production starch-equivalent and a much higher yield of digestible protein per acre. The pasture herbage in the first season had a nutritive ration ranging from 1 : 2 to 1 : 3; and, on the assumption that a 12-cwt. cow would consume 30 lb. of dry matter per day, such grass should more than supply the requirements of a cow giving 4 gallons of milk per day. Supplementary foods, if any, used on such a pasture would need to be rich in carbohydrates.

The problems in animal nutrition remaining to be solved are many and varied; and it appears likely that in the realm of home-grown fodders, the co-operation of soil-chemist, plant-physiologist, and bio-chemist may be necessary, if the speediest results and those best calculated to meet the economic requirements of the farmer in feeding his stock are to be

attained. These problems confront not only those of us who work in this country, but also workers in the Empire overseas; and it is inspiring to note how keen an interest the Dominions are taking, as evidenced by the Imperial Agricultural Research Conference, in all aspects of scientific research bearing on the practice of farming.

VICTORIA, B.C.:
Printed by CHARLES F. BANFIELD, Printer to the King's Most Excellent Majesty.
1930.

5M-1230-2761

AGRICULTURE
FORESTRY
LIBRARY

University of British Columbia Library
DUE DATE

FORM 310